ASSOCIATIONS OF MATERNAL HEALTH CARE STRUCTURE AND PROCESS QUALITY WITH OUTCOMES IN MALAWI

By

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ABSTRACT

Background: Recent trends in maternal health in low- and middle-income countries (LMIC) show increasing health service utilization without anticipated improvement in outcomes, leading some to question the health care quality. Programs seeking to improve health care quality frequently use the Donabedian quality of care framework as a guide. This study examined the associations among the different dimensions – structure, process, and outcome – of the Donabedian quality of care framework in the Malawi maternal health care context.

Methods: Using data from the 2013 Malawi Service Provision Assessment (SPA), two measures of antenatal and labor and delivery (L&D) care structure – infrastructure and human resources – and two measures of process – technical and interpersonal – quality were constructed. Spearman's correlations were used to estimate associations between structure and process elements in antenatal (N=400) and L&D facilities (N=179). At facilities with observation data from both services (N=149), associations of quality elements between services were assessed. Multilevel path analysis was used estimate direct and indirect effects of structure and process quality elements on outcomes; first patient satisfaction among all antenatal patients (N=2000) and facilities (n=400), and second intention to deliver at the same facility among antenatal patients at facilities which offered both services (N=1817, n=360).

Results: Structure and process quality was poor in both antenatal and L&D care. Structural quality was positively associated with technical process quality. Neither element of structural quality was associated with interpersonal process quality. Technical, but not interpersonal, process quality was correlated in the two service areas. Better interpersonal process quality, hospitals, private health facilities, as well as lower patient education were significantly associated with higher patient satisfaction. Hospitals, lower patient education, and higher parity were significantly and directly associated with increased intention to deliver at the same facility.

Infrastructure had a significantly negative indirect effect on intention to deliver at the same facility through technical process.

Conclusion: These data do not support the Donabedian quality of care framework. This study highlights the need to focus on quality of maternal health care in Malawi, as well as the need to better understand how measurement of quality of care influences associations with patient outcomes.

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Chapter 1: Introduction and Specific Aims

1.1 INTRODUCTION

Quality of maternal health care at facilities is thought to be higher than the care provided at home by traditional birth attendants or other non-formal health care workers. For this reason, there has been a push to increase the proportion of births occurring at facilities in low- and middle-income countries (LMIC). These efforts have been successful; many LMIC have seen facility delivery rates increase dramatically over the last decade. In Malawi, facility delivery increased from 57% in 2004 to 91.4% in 2015 [1, 2].

Concurrent with this increase in facility delivery, maternal and neonatal mortality have decreased. In Malawi from 2004 to 2015, the maternal mortality ratio decreased from 984 to 439 per 100,000 live births and the neonatal mortality rate decreased from 27 to 22 per 1000 live births [1, 2]. While these decreases are significant, the maternal mortality ratio and neonatal mortality rate are still elevated compared to the Sustainable Development Goal of 70 maternal deaths per 100,000 live births and 12 neonatal deaths per 1,000 live births by 2030 [3][1]. With over 90% of women in Malawi now delivering in a facility, the fact that the maternal mortality ratio and neonatal mortality rate still fall short of these goals has prompted some to question the quality of care provided to mothers and children at facilities [4].

Lack of a universal operational definition of quality of care makes it challenging to assess the quality of care provided at facilities [5, 6]. Authors of the most recent definitions attempt to encompass the complex, multi-dimensional nature of quality, from the perspective of both the provider and the patient [7, 8]. Recent definitions elaborate on Donabedian's framework, which conceptualizes quality of care along three dimensions: structure, process, and outcome [9]. While Donabedian himself wrote about the complex relationships among these three dimensions [10],

[1] The Sustainable Development Goals represent the targets of the 2030 Agenda for Sustainable Development, adopted in 2015 by 193 countries. The Agenda aims to promote prosperity while protecting the planet using strategies that build economic growth and address a range of social needs. The health goals, including the reduction of the maternal mortality ratio and the neonatal mortality rate, reflect the belief that ensuring healthy lives and promoting the well-being for all at all ages is essential to sustainable development.

many applications of his framework use a linear mechanism, where good structure leads to good process which leads to good outcomes [11-13]. Little is known about how the dimensions are associated in practice, particularly in the case of maternal health care in LMIC.

This study focused on antenatal and labor and delivery care provided at facilities in Malawi. The three specific aims were to:

Aim 1: Evaluate associations among four elements of quality of antenatal and labor and delivery care: two structure elements – infrastructure and human resources – and two process elements – technical and interpersonal.

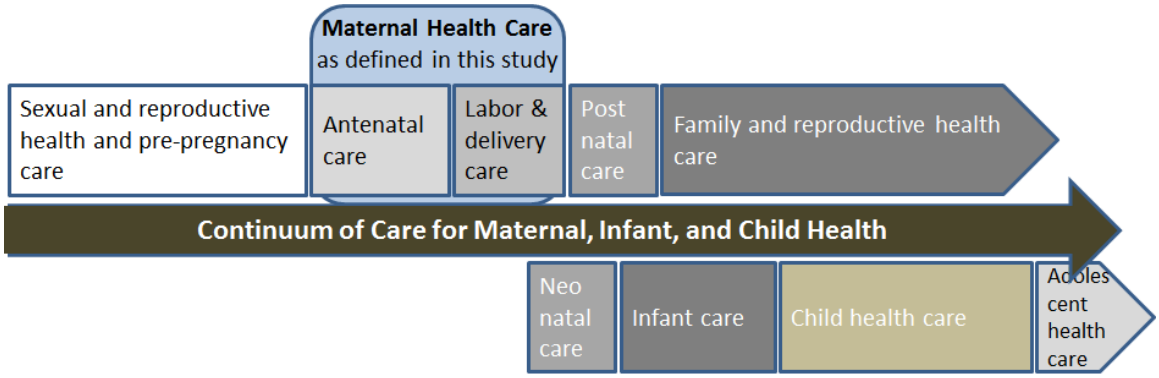
Aim 2: Evaluate the association of structure and process quality of antenatal care with patient satisfaction with antenatal care.

Aim 3: Evaluate the association of structure and process quality of antenatal care with patients' intended delivery location among women who attend antenatal care at a facility with labor and delivery care services.

1.2 BACKGROUND

This study examined associations between the dimensions of quality in the context of the continuum of care for maternal, newborn, and child health. This continuum has been used to describe the different but related health care services needed throughout the lifecycle (See Figure 1.1.) – pre-pregnancy care, antenatal care, labor and delivery care, postnatal care, and childhood health care [14]. Continued engagement of women and children along each phase of the continuum has become a key strategy for reducing maternal and newborn mortality and improving maternal and neonatal health and wellbeing [14]. This study focused on one portion of the continuum – the transition from antenatal care to labor and delivery. For the purposes of this dissertation, "maternal health care" refers to both antenatal and labor and delivery care.

Figure 1.1: Continuum of care for maternal, newborn, and child health. Adapted from Kerber et al. [14]



Data for this study came from a facility census in Malawi. These data were used to measure four elements of the structure and process dimensions of quality of antenatal care and the quality of labor and delivery care. These four elements include two structural measures – infrastructure and human resources – and two process measures – technical and interpersonal. The study first used correlation to test associations among these four elements in antenatal and labor and delivery care, and then used multilevel path analysis to test associations among these four elements and associations of each element with two outcomes, patient satisfaction and intended delivery location.

This study fills a gap in the research literature on quality of maternal health care in LMIC, which has focused largely on antenatal care attendance and facility delivery. While some studies have measured associations of structure and process quality with outcomes in maternal health care in LMIC [6, 15-21], no studies were identified which examined associations among structure and process elements of quality and also associations of those elements with outcomes.

1.3 DISSERTATION OVERVIEW

The dissertation is presented in five chapters. This chapter introduced the study aims and briefly discussed their background. The second chapter presents a literature review, the rationale for the study, and its conceptual framework. The third chapter presents methods, including the

study design, data sources, measurement approaches, and analytic plan. Chapter four presents results. Chapter five presents a discussion of the study results, study strengths and limitations, and the programmatic, policy, and research implications.

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Chapter 2: Literature Review and Conceptual Framework

2.1 INTRODUCTION

This chapter provides a review of the literature on quality of care, patient satisfaction, and intention to deliver at a health facility. Section 2.2 describes the concept of quality of care. It starts with the definition of quality of care in general, followed by definitions of quality of maternal health care specifically. The section closes with a review of approaches to measurement of quality of maternal health care and a discussion of the multilevel determinants of quality of care. Sections 2.3 and 2.4 present the relevant outcomes of interest in this study, patient satisfaction and intended delivery location, respectively. Each section begins with the presentation of the definition(s) of the concept, along with important theoretical underpinnings and measurement approaches. Each section then continues with a discussion of evidence on associations of each outcome with quality of care, followed by other multilevel determinants of each outcome. This chapter closes with Section 2.5 which synthesizes the reviewed literature in the description of the conceptual framework which guides this research.

2.2 QUALITY OF CARE

2.2.1 Definition

Quality of care is widely recognized as an essential component of health care provision. However, the definition of quality of care remains nebulous despite the fact that many conceptualizations of the dimensions and elements of quality of care have been developed [1-6].

In 1966, Donabedian identified three dimensions of quality of health care: structure, process, and outcome [7].

- **Structure** relates to the setting in which care occurs. This consists of two broad elements. The first is the condition of the facility itself and the availability of relevant equipment and medications for facilities that provide maternal care in LMIC, which together can be referred to as infrastructure. Examples of structural elements for maternal care in LMIC include whether a facility has a functioning

blood pressure cuff or has non-expired magnesium sulfate to treat a pregnant woman with pre-eclampsia. The second element is human resources. Examples of human resources elements for maternal care include whether or not there is a midwife or other skilled delivery attendant on duty 24 hours a day.

- **Process** relates to the giving and receiving of care. Donabedian identifies two elements of process – technical and interpersonal. The technical element compares actual clinical care with best practice. One example of a technical element of maternal care in LMIC includes whether a woman in labor was appropriately monitored. The interpersonal element considers the social-emotional elements of communication by the provider with standards for effective communication [8]. Examples of interpersonal elements of maternal care in LMIC include whether the provider explains what is happening to the patient or allows the mother to labor in traditional birthing positions.
- **Outcomes** relate to the impact of care on patients. Examples of outcomes include health status, functioning, satisfaction, and health behaviors. For maternal care they include satisfaction with health services received, health behaviors such as adherence to provider recommendations, intentions such as subsequent care seeking for labor and delivery or postnatal care, and health status such as maternal morbidity or mortality.

More recent definitions have expanded the scope of the quality definition beyond the facility and clinical encounter to health systems. In 2001, an Institute of Medicine (IOM) report detailed a strategy to improve the United States health care delivery system with the goal of achieving six specific aims, akin to six dimensions of quality. The report stated that high quality health care should be: (1) safe, by "avoiding injuries to patients from the care that is intended to help them"; (2) effective, by "providing services based on scientific knowledge to all who could

benefit, and refraining from providing services to those not likely to benefit"; (3) patient-centered, by "providing care that is respectful of and responsive to individual patient preferences, needs, and values, and ensuring that patient values guide all clinical decisions; (4) timely, by "reducing waits and sometimes harmful delays for both those who receive and those who give care"; (5) efficient, by "avoiding waste, including waste of equipment, supplies, ideas, and energy"; and (6) equitable, by "providing care that does not vary in quality because of personal characteristics such as gender, geographic location, and socioeconomic status" [3].

In 2006, the World Health Organization (WHO) applied these same six dimensions in their definition of health care quality. Their definition of quality adapts the "timely" dimension by expanding it to be "accessibility", and defining it as 'delivering health care that is timely, geographically reasonable, and provided in a setting where skills and resources are appropriate to medical need' [9].

This study used Donabedian's definition, as it is the most commonly applied quality of care model [10], and is the basis for frameworks of maternal health care quality, to be discussed in sections 2.2.3.

2.2.2 **Conceptualizations of antenatal care quality**

There is a paucity of conceptual work around quality of antenatal care in the literature [11]. While standards and guidelines for technical elements of the process of antenatal care exist, no frameworks were identified which apply the structure, process, and outcome dimensions of quality specifically to antenatal care. Evaluations of the quality of antenatal care have used general frameworks for quality [12-14].

A 2015 systematic review to assess what matters to women in antenatal care identified one overarching theme: Women want and need a positive pregnancy experience. The four subthemes identified in that review were:

1. maintaining physical and sociocultural normality;
2. maintaining a healthy pregnancy for mother and baby (including preventing and treating risks, illness and death);
3. effective transition to positive labor and birth;
4. and achieving positive motherhood (including maternal self-esteem, competence, autonomy) [15].

The 2016 World Health Organization (WHO) recommendations on antenatal care built upon this review and are based around the overarching theme of providing a positive pregnancy experience. However, they do not provide specific recommendations beyond technical elements of process quality of care, such as the recommendation that all pregnant women should receive a tetanus toxoid vaccination, and programmatic elements, such as women should carry their own case notes during pregnancy [16]. Also in 2016, the WHO developed a multi-dimensional framework for labor and delivery quality, which will be discussed in the following section, and noted that this framework can be applied to antenatal care [17].

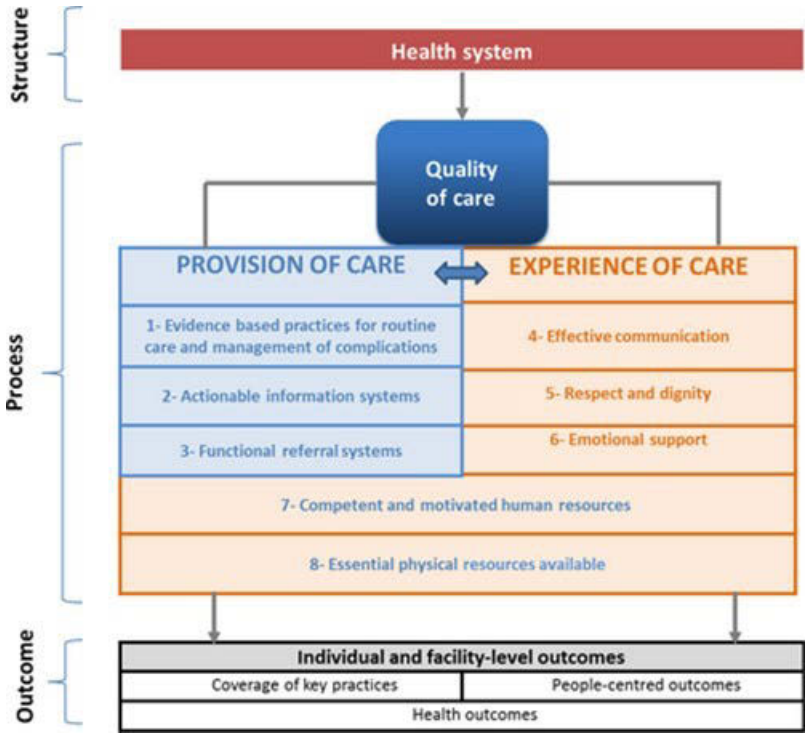
2.2.3 **Conceptualizations of labor and delivery quality**

In 2000, Hulton developed a quality of care framework specific to labor and delivery services. Hulton's framework focuses on the process of care as defined by Donabedian. It has two elements that align with those of Donabedian's process quality of care dimension but have different names. Hulton's "provision of care" is analogous to Donabedian's technical element; her "experience of care" is analogous to Donabedian's interpersonal element [5]. Hulton went on to detail the components which comprise each of these elements, as shown in Figure 2.1.

Figure 2.1: Hulton's quality of care framework for labor and delivery services [2]

In 2015 the World Health Organization (WHO) developed a quality of care framework (See Figure 2.2.) that builds on that of Hulton [6].

Figure 2.2: WHO quality of care framework for facility-based maternal and newborn care around the time of childbirth [3]



The two frameworks are similar in some ways:

- A focus on the process of care as defined by Donabedian, and
- A description of the same elements of quality:
    - Provision of Care,
    - Experience of Care,
    - Competent and Motivated Human Resources, and
    - Essential Physical Resources [6].

Yet the Hulton and WHO frameworks differ in two ways:

- The relationship of the different elements:

    - Hulton places human and physical resources under provision of care and experience of care, while the WHO framework separates them out as important in their own right.
- Their scope:
    - The WHO framework encompasses maternal and newborn care around the time of childbirth, while Hulton's framework only applies to care of the mother during labor and delivery.

2.2.4 **What are we measuring when measuring "quality"?**

Measuring quality of care is challenging. The multi-dimensionality of quality of care makes it difficult to characterize quality with a single set of indicators from routinely collected administrative data or a survey [18]. In addition there is a general shortage of reliable facility level data, particularly in LMIC [19].

In the literature, studies assessing process quality frequently measure perceived rather than observed quality [20]. Both perspectives are valuable. While observed clinical process quality is essential for good patient health outcomes, perceived process quality is an important driver of health care utilization [21]. The two perspectives are not consistently associated [22-24]. From a programmatic perspective, it is crucial to have data on observed process quality, as this is where programs can intervene by providing additional supervision or mentoring to health care workers. For this study, process quality is measured using observations of patient-provider interactions, however, the literature uses both observed and perceived measures, so this section will include evidence on both types of measures.

Much empirical research on the quality of labor and delivery care has assessed quality using measures of only two dimensions: the structural dimension, specifically human resources and infrastructure elements, and the process dimension, specifically the technical element [22, 25-

28]. This is not surprising, since these elements are the easiest to quantify and measure. With the development of the 2015 WHO framework [6], which includes interpersonal quality, recent studies incorporate interpersonal elements into measures of labor and delivery [29-31]. There is a growing evidence base on respectful maternity care, which focuses on the quality of interpersonal elements of labor and delivery care specifically [31-34].

A review of the antenatal care quality literature shows a similar focus on the structure and process dimensions of quality of care, with an emphasis on the infrastructure element of structure and the technical element of process. Of fourteen studies which sought to describe antenatal quality of care in LMIC, ten included both the structure and process dimensions [11-14, 22, 27, 35-38]. Four only assessed technical quality [39-42]. Of the ten which included both structure and process, four included measurement of infrastructure, technical and interpersonal process [35-38]; two included measurement of infrastructure, human resources, and technical process [22, 27]; and one included measurement of human resources and technical process quality [13]. Only three studies of the quality of antenatal care assessed both elements of both dimensions of quality [11, 12, 14].

A 2016 literature review of 84 quantitative studies[2] of the quality of labor and delivery quality of care in LMIC settings found that nearly all (70) had used some indicators of process [20], as shown in Table 2.1. Over half of the studies included an outcome measure.[3]

[2] The literature review included studies from high-income countries as well, but here the focus is on the sub-set of 84 studies with quantitative indicators of maternal labor and delivery care quality from LMIC.

[3] The annex provided by the author details whether indicators used in each study represented the three quality dimensions of structure, process and outcome, however not all indicators used in each study were shown in the annex. Therefore, it was not possible to further disaggregate the indicators into infrastructure, human resources, technical, interpersonal, health status, and satisfaction elements.

Table 2.1: Quality dimensions included in published studies of labor and delivery quality assessment in LMIC [20]

Structure	Process	Outcome	Number of studies
	■	■	27
	■		22
■	■	■	11
■	■		10
		■	9
■			4
■		■	1
		Total	84

Quality dimension assessed	■
Quality dimension not assessed	

Nearly all studies included some measure of structure. Within the process dimension of quality, measures of the quality of labor and delivery care rarely capture both its technical and interpersonal elements.

An earlier review assessed instruments developed for evaluating the quality of obstetric care in LMIC from the grey and published literature [43]. Of the 37 instruments identified, 21 included measurement of the process of care; of these, only six included measures of both the technical and interpersonal elements [43] (See Table 2.2.). When outcomes were measured (15), they were likely to be health outcomes (12) rather than satisfaction measures (3).

Table 2.2: Quality dimensions and elements included in 37 instruments for measuring quality of labor and delivery care in LMIC [43]

Dimension	Structure		Process		Outcome		
Element	Infra-structure	Human Resources	Technical	Inter-personal	Health status	Satisfaction	Number of instruments
	■	■					9
	■	■	■		■		7
		■					4
	■						3
	■	■	■	■	■		3
	■		■	■			2
		■	■		■		2
			■				1
	■	■	■				1
	■	■	■	■			1
	■			■			1
		■		■		■	1
	■	■		■		■	1
	■			■		■	1
						Total	37

Quality element assessed	■
Quality element not assessed	

2.2.5 **How do we measure quality?**

When seeking to measure the different dimensions of quality, there are several measurement approaches available to choose from, especially for process and outcome dimensions.

2.2.5.1 *Structure*

Measures of structural quality typically come from facility assessments or surveys [44]. In LMIC, standardized facility assessments are a major source of structural quality data. Implementation of these assessments is resource-intensive and is typically supported by donor organizations such as the WHO; the World Bank; the Global Fund for AIDS, Tuberculosis, and Malaria; and the United States Agency for International Development (USAID). Two commonly used facility surveys are the Service Availability and Readiness Assessment (SARA), developed and funded by WHO, and the Service Provision Assessment (SPA), developed by the

Demographic and Health Survey Program, funded by USAID. This study used data from the 2013-2014 Malawi SPA.

2.2.5.2 *Process*

There are five main methods for measuring process quality during patient-provider interactions [45, 46]. These methods are:

1. Exit interviews with patients or caretakers about provider performance,

2. Standardized simulated patients,

3. Review of medical records,

4. Direct observation of actual care using a structured checklist,

5. Simulation, demonstration, or clinical vignettes.

Exit interviews best measure the more subjective aspects of process quality, such as interpersonal characteristics, as technical aspects of care might be less well understood by patients and therefore less reliably reported [47]. In addition, while exit interviews reduce recall bias since they are done immediately after the patient-provider encounter, conducting interviews at the facility may introduce courtesy bias by making patients hesitant to express their true opinion.

A standardized simulated patient is an individual who is trained to depict a specific medical case and then recall his or her interactions with the provider [46]. Simulated patients are not limited to be humans – anatomical models have been developed to be used as simulated patients. These anatomical models are used primarily to train birth attendants in obstetric and neonatal care but can also be used to evaluate quality of care. While standardized simulated patients are seen as a gold-standard for measuring the quality of care patients receive when they enter a facility [48], this approach is limited to assessing quality of care in the case of medical

conditions that can be realistically portrayed without harm to the simulated patient, as well as being resource-intensive and difficult to implement on a large scale [47].

Medical record review is the least intrusive and expensive method for assessing quality, though it is limited by the quality of the data in the records, which may be particularly weak in developing country settings [45]. Also, in many countries, data entered is limited by the pre-determined columns in the register, therefore many procedures go unrecorded. This method is limited to measuring technical process quality, as interpersonal process quality could not be objectively noted by the provider him or herself.

Direct observation is also considered a gold standard for quality assessment [45]. Although providers are likely to modify their behavior under observation, research has shown that provider behavior changes the most when the observer enters the clinic and returns to normal after the first ten to fifteen patients [49]. In the context of developing countries with largely illiterate populations, observation has demonstrated the highest overall sensitivity and specificity [50].

While simulations and demonstrations aimed at assessing practical skills and clinical vignettes or other types of knowledge assessments are simple to implement, they have been shown to be poor predictors of actual performance [48, 49, 51].

2.2.5.3 *Outcome*

Quality of care outcomes can vary from individual level patient satisfaction or quality of life, to facility level morbidity and mortality rates. Individual level attitude or experience outcomes, as well as self-reported health outcomes can be collected with patient questionnaires or interviews. Questionnaires or interviews allow researchers to collect data which is not typically contained in a medical record. However questionnaire responses are vulnerable to multiple types of bias and are difficult to validate [52]. Individual or aggregated health outcome data may be

extracted from medical records. Some type of medical record is typically available, and these records contain much relevant patient outcome data. Medical record data may be incomplete or missing, is unstandardized, and may be inconsistently recorded [52].

2.2.6 **Associations among dimensions of quality**

Donabedian's early work on quality discusses the complex relationships among the structure, process, and outcome dimensions [7], while his later work simplifies the relationships by stating that good structure increases the likelihood of good process which increases the likelihood of good outcomes [8]. Associations among the dimensions have been rarely tested in empirical studies of health services. A review of the literature[4] revealed only six studies which explicitly sought to simultaneously examine associations between all three of Donabedian's dimensions of quality in health care settings [53-59]. Only one of these studies was done in an LMIC [53]; none pertained to maternal health care.

These studies revealed complex and inconsistent associations among Donabedian's dimensions. Three studies found that structure was associated with process and outcome, and process was associated with outcome [53, 54, 56]. Another found that structure was associated with process, and process associated with outcomes [55]. Another study looked at correlations between pairs of dimensions in a trauma setting, finding that good structure was correlated with good process, and good process was correlated with good outcomes, specifically lower readmission rates and lower length of stay in the hospital, but that good structure was correlated poor outcomes, specifically with increased mortality [57]. Another study looking at nursing facilities found both positive and negative correlations between good structure indicators and

[4] An initial Pubmed search for studies with "Structure" AND "Process" AND "Outcome" in the title was conducted. All available abstracts were reviewed, identifying 8 studies assessing the relationship between the dimensions. Citations of those studies were also reviewed to identify additional studies which should be included.

poor process indicators, as well as both positive and negative correlations between poor process indicators and poor outcomes [58].

No studies were identified that assessed associations between structure, process, and outcomes in maternal health. The existing quality of care literature in maternal health frequently cites Donabedian's quality framework, or the Hulton or WHO frameworks which build upon Donabedian, as a theoretical model [11-13, 22, 25-27, 60-63]. However, as discussed earlier, these studies measure quality one of three ways:

1. As a unidimensional construct by aggregating measures from the three quality dimensions – structure, process, outcome – into one;
2. As a unidimensional construct by including only process or structure as the sole measure of quality;
3. As multi-dimensional by differentiating between the dimensions but then including the structure and process dimensions as separate covariates in multivariate analysis against some outcome [64].

The two latter approaches allow for assessment of the association between structure and outcome and/or process and outcome, but none of these approaches allow for elaboration of the associations among all three dimensions of quality.

2.2.7 **Determinants of quality of maternal health care**

This study focused on quality of care in maternal health care: antenatal and labor and delivery care, specifically. While many studies have assessed determinants of use of maternal health services, only six quantitative studies were identified which examined the determinants of observed structure and/or process quality of maternal health care in LMIC [39, 64-68]. This dearth of studies may be due to the complexity in defining and measuring quality, as discussed in the previous sections, and a lack of data.

Determinants of the outcome dimension of quality of care, specifically of the two outcomes of interest in this study, will be discussed later in this chapter.

2.2.7.1 *Facility determinants*

Hospitals have been shown to have better structure and process quality care when compared with health centers [64, 66], while the evidence on operating authority, that is, whether a facility is operated by the government or by a private organization, is mixed [39, 64, 67].

2.2.7.2 *Patient determinants*

Lower parity, higher level of education, higher household income, older age, earlier initiation of antenatal care, and living in an urban area have all been associated with receipt of higher technical process quality of maternal health care [39, 65-68]. Evidence of an association of marital status with quality of maternal health care received has been mixed [39, 68].

2.3 PATIENT SATISFACTION

In recent years, patient satisfaction has become an increasingly important outcome indicator of the quality of care. This shift has been driven by a new focus on person-centered care (PCC), defined by the Institute of Medicine as "care that is respectful of and responsive to individual patient preferences, needs, and values, and ensuring that patient values guide all clinical decisions." [3] This focus on PCC has extended to maternal health in LMIC [69, 70].

2.3.1 **Definition**

There are many definitions of patient satisfaction. Satisfaction can relate to many aspects of health care: care in a specific health care encounter, care over many encounters, the patient's relationship with a provider over time, or with a health system overall. This section will generally refer to satisfaction with a specific health care encounter.

Most definitions of satisfaction have two common features. First, satisfaction is an emotion grounded in the alignment of an individual's perceived experience with what was

expected from that experience [71-74]. Second, that satisfaction can be different for different aspects of a health care encounter [75]. For example, satisfaction for the same experience can differ for the three dimensions of quality: structure, process, and outcome.

Conceptualization of patient satisfaction has closely followed that of quality of care. While a patient can be satisfied or dissatisfied with clinical outcomes, satisfaction is also seen as an outcome in and of itself. Donabedian viewed patient satisfaction as an aspect of the outcome dimension of quality, saying "achieving and producing health and satisfaction, as defined for its individual members by a particular society or subculture, is the ultimate validator of the quality of care" [76].

2.3.2 **Theory and conceptual models of patient satisfaction**

Many different conceptualizations of patient satisfaction have been put forth in divergent areas of study, including health and psychology. This section describes three conceptualizations of patient satisfaction. The first two emanate from the most frequently applied theories of patient satisfaction in maternal health [77] – fulfillment and discrepancy theory. The third conceptualization was proposed by Linder-Pelz [78].

2.3.2.1 *Fulfillment theory*

Fulfillment theory holds that a patient's satisfaction of dissatisfaction is determined by the absolute difference between his or her expectations and his or her experience of care [79]. In this context, the larger the gap between expectations and experiences, the greater the satisfaction or dissatisfaction.

2.3.2.2 *Discrepancy theory*

In comparison, discrepancy theory defines satisfaction as the perceived discrepancy between what was expected and what was experienced *as a proportion of what was expected* [78]. In this theory, the level of the expectation matters. For example, discrepancy theory holds

that a woman would be more satisfied if she expected care at a 3 and received care at a 4 than if she expected care at a 7 and received care at an 8 because the one-unit difference is a greater proportion of 3 than of 7. This is in contrast to fulfillment theory, which would estimate the same level of satisfaction in both scenarios.

2.3.2.3 *Linder-Pelz's model of patient satisfaction*

The third conceptualization of patient satisfaction was put forth by Linder-Pelz. Her theory built upon Fishbein and Ajzen's attitude theory, which characterized satisfaction with an encounter as an attitude which is a function of the strength of the belief regarding the value of the encounter and the evaluation of the experience of the encounter [80, 81].

Linder-Pelz focused in on satisfaction with health care and proposed five determinants of patient satisfaction: expectations, value, entitlement, occurrences, and interpersonal comparisons [82]. For example, a woman's satisfaction with her antenatal care providers would depend on whether she expected positive interactions with her providers, thought positive interactions were important, and felt that she deserved positive interactions; how positive she perceived interactions in the encounter in question to be; and how those interactions compared to interactions in previous encounters.

2.3.2.4 *Evidence for patient satisfaction models*

There is little empirical evidence to support the validity of any of these three conceptualizations of patient satisfaction. One challenge is that patient expectations are rarely assessed in advance of a health care encounter. As a part of the development of her theory, Linder-Pelz conducted the only identified study testing the validity of different conceptualizations of satisfaction. She tested hypotheses based on the fulfillment theory, discrepancy theory, as well as her own model of the determinants of patient satisfaction. Data on health care values, expectations, and sense of entitlement to care, were collected just before seeing a physician, as

well as each patient's post-visit satisfaction with different aspects of his or her care. Results showed that expectation was the strongest determinant of satisfaction, but even then, it explained less than 10% of the variation in one aspect of patient satisfaction, physician conduct [83]. Linder-Pelz's findings did not support the fulfillment theory, nor her own model, but did support the discrepancy theory of patient satisfaction [83]. Some have argued that her measures were not appropriate; however, no alternative studies have been conducted which test conceptualizations of satisfaction with alternative measures [78].

2.3.2.5 *Positive versus negative information and patient satisfaction*

While yet to be incorporated into a formal model or theory, recent research has explored the role of positive versus negative information in determining patient satisfaction. Evidence has shown that negative information is processed in a fundamentally different way than positive information, and that the type of information received during a health care encounter may be an additional determinant of satisfaction [84, 85]. Applied to a maternal health care context, a woman who expects her clinical care to be excellent, perceives the care she received as excellent, and perceives the resulting clinical outcome as good would have a positive emotional response and be satisfied. In contrast, a woman who expects her clinical care to be excellent, and perceives the care she received as excellent, but perceives the resulting clinical outcome to be poor would have a negative emotional response and would be dissatisfied, or less satisfied than if she perceived the resulting outcome as good.

2.3.3 **Measurement**

Approaches to patient satisfaction measurement have varied, with some instruments focusing on different aspect of care, including specific encounters with health care providers (e.g. FACIT-TS-PS [86]), the facility where the encounter occurred (e.g. Client Satisfaction Questionnaire [87]), and the healthcare systems at large (e.g. Patient Satisfaction Questionnaire [88]).

Patient satisfaction is a multi-dimensional construct [89-91]. Composite measures of patient satisfaction have been modeled both as scales with multiple sub-scales [92, 93], and as indices [94-96]. Ware and colleagues conducted much of the early work in measuring satisfaction, identifying seven dimensions of patient satisfaction that cover all the levels of health care mentioned in the previous paragraph [88]. Three of these dimensions align with the dimensions of quality in this study: infrastructure, technical quality, and interpersonal process quality. Ware refers to the last of these as "communication style". The other four dimensions of Ware's measure do not align with the definition of quality used in this study: availability, accessibility/convenience, finances, and continuity.

In this study, patient satisfaction was assessed with a composite measure, an index which includes indicators of satisfaction with a specific encounter with a health care provider, as well as satisfaction with several aspects of the services provided by the health facility. Creation of the measure will be discussed in more detail in Chapter Three.

2.3.3.1 *Skew*

A common characteristic of patient satisfaction data is a high mean and a strong negative (left) skew. A meta-analysis of 221 patient satisfaction studies in high-income countries sought to determine mean satisfaction levels across all the studies [97]. Satisfaction values from the original studies were transformed to be equally spaced on a scale of 0 to 1, irrespective of their original scale values (*e.g.,* 1-5, "very dissatisfied" to "very satisfied"). The mean satisfaction score across all studies was 0.76 [98].

There are several explanations for this skewed distribution. First, most patients may actually be satisfied with the care they received. Qualitative assessment of the difference between "satisfied" and "very satisfied" patient ratings revealed that satisfaction was associated with care that was average, while care above average resulted in very satisfied patients [98]. If a patient's

expectation for care received was low and the experienced quality of care was aligned with that, the quality would match their expectation and it would follow that most patients would be satisfied with their care.

Second, there may be social desirability bias, where respondents may be more likely to answer questions in a manner that will be viewed favorably by others [99]. This bias can be exacerbated when conducting interviews at the facility itself, which can make patients more likely to provide a positive response.

Finally, the way questions are framed can bias the responses. A recent study found that patients who responded to a patient satisfaction survey with negatively framed questions had significantly lower levels of satisfaction compared to patients who responded to the same survey, but with positively framed questions [100]. A large proportion of patient satisfaction surveys phrase questions positively, which may contribute to the common skew of patient satisfaction data [100].

In this study, patients were interviewed at the clinic, but in a location with auditory privacy [101]. The patient satisfaction questions were framed neutrally.

2.3.3.2 *Timing*

Timing may influence a patient's ratings of satisfaction. The direction of this effect is unclear. Some studies have observed a decline in the level of satisfaction as the time since the encounter in question increases [102-104]. For example, evidence from Norway showed that the longer the time between the medical encounter and the satisfaction assessment, the poorer the patient experience rating of three of six measures: doctor services, information about examinations, and organization [105, 106]. Other studies have found no effect of time on reported patient satisfaction [107, 108].

There are several potential explanations for these findings. First, negative experiences may become more salient than positive ones as time passes. Second, satisfaction may decrease as more information is obtained and a more accurate understanding of an encounter is developed [109] or as an individual has new experiences, such as additional encounters with health care, which may alter the initial perception of an experience. Finally, initial satisfaction may be linked to the patient-provider interaction, but over time satisfaction may reflect outcomes of care, such as whether or not symptoms have resolved and if there was a need for repeat visits [110].

In this study, satisfaction was assessed immediately after the patient's encounter with a health care provider, while the patient was still in the clinic.

2.3.4 **Associations of quality of care and patient satisfaction**

Many studies have looked at the association of specific elements of structure and process quality of care with patient satisfaction. Overall, three of the elements of quality of care used in this study are typically positively associated with patient satisfaction – infrastructure, human resources, and interpersonal care. Infrastructure and human resources have shown positive associations with patient satisfaction for both general health care and for maternal care [38, 111-116]. The positive association of interpersonal process quality with patient satisfaction is especially consistent in maternal health care [37, 61, 115, 117-120].

Evidence is mixed regarding the association of technical quality of care with patient satisfaction. Some studies have found no association [22, 61], while other studies show significant positive associations [60, 121, 122].

2.3.5 **Other determinants of patient satisfaction**

2.3.5.1 *Facility determinants*

Certain facility characteristics may influence a patient's satisfaction with the care they received. The ease of access of a facility has been shown to be associated with greater satisfaction

for maternal health care in Nigeria, and Pakistan [123, 124], however studies in Bangladesh and Sri Lanka showed no association [125, 126], and a recent study in Ethiopia showed that women who come from further away have higher odds of being satisfied with antenatal care [127]. Perceived affordability of care has been identified as a significant determinant of increased satisfaction with maternal care services in India, Kenya, and Pakistan [120, 124, 128]. Facility operating authority (private versus public) has been significantly associated with satisfaction in maternal health care, with women receiving care at private facilities having higher satisfaction [12, 22, 114, 129]. The type of facility, whether it is a hospital or a health center, may also influence patient satisfaction, although evidence here is mixed [22, 111]. The location of the facility in an urban compared to a rural area may also influence satisfaction, however again, evidence here is mixed [111, 130].

2.3.5.2 *Individual determinants*

Individual characteristics have also been shown to influence a patient's satisfaction with care. Higher maternal age, higher parity, and lower education have been shown to be positively associated with satisfaction [60, 114, 126, 131-134]. As discussed earlier, the outcome of the specific encounter, such as the delivery outcome in the case of maternal health care, has been shown to affect satisfaction, with positive outcomes leading to increased satisfaction [128, 135-137]. Patient satisfaction has been found to decrease with increasing number of antenatal care visits [134].

2.4 INTENDED DELIVERY LOCATION

2.4.1 **Definition**

In this study, intended delivery location is interpreted as the outcome of two decision points. First is the decision to deliver at a health facility as opposed to at home or in another location, and second is the decision to deliver at one specific health facility versus another.

2.4.2 **Theory**

This section will describe the theory behind three concepts underlying intended delivery location: behavioral intention generally, health service utilization, and facility choice.

2.4.2.1 *Behavioral intention*

In 1967, Fishbein proposed the Theory of Reasoned Action (TRA), which asserted that intention was the most important predictor of behavior [138]. Under this theory, behavioral intention is the result of an individual's attitude toward the behavior and his or her perceived subjective norms. In this context, a pregnant woman who had a positive attitude towards facility delivery and who thought that facility delivery was a normal thing to do in her community would be likely to intend to deliver at a health facility.

In 1991, Ajzen posited the Theory of Planned Behavior (TPB), which built upon the TRA by adding perceived behavioral control as another construct which influences an individual's behavioral intention [139]. Under TPB, perceived behavioral control is thought to be determined by an individual's degree of self-efficacy and perceived power. Under this theory, the woman who had a positive attitude towards facility delivery and who thought that facility delivery was a normal thing to do in her community would be less likely to intend to deliver at a health facility if she was dependent on public transportation and such transportation was unreliable.

2.4.2.2 *Health service utilization*

Turning to health care behaviors specifically, Andersen's model of health service utilization is commonly used to determine factors in the choice of whether or not to access health care [140]. This model incorporates many of the individual factors detailed in the TRA/TPB, as well as external factors such as the health care system and the social environment. Andersen's model defines three types of factors to predict health service use: first, predisposing characteristics such as demographics, social position, and health beliefs; second, enabling

resources such as family and/or community support; and third, the individual's perceived need for health care [140]. In this context, a woman who believes that risky pregnancies have better outcomes with a facility delivery, who has the support of her family to deliver at a facility, and who believes that her pregnancy is a risky one would be likely to deliver at a facility.

2.4.2.3 *Facility choice*

There is limited theoretical discussion about how patients choose specific providers or facilities. Physical accessibility, particularly distance, is frequently cited as a factor in the choice of facility, particularly in the choice of whether or not to deliver in a facility, with increasing distances associated with decreased facility delivery [141-145]. The nature of labor and childbirth as an unpredictable and potentially precipitous event likely contributes to this association.

However, recent research suggests that there are other important factors associated with the selection of health facility. In East and Southern Africa specifically, there is evidence that patients intend to [70, 146, 147] and actually do [148-151] bypass their closest facility in favor of facilities further away for labor and delivery and other maternal and child health services.

Leonard's active patient model incorporates some of the factors that might explain why one would bypass the nearest health facility for health care [152]. This model, rooted in economics, posits that although many patients are passive in the presence of medical personnel, most patients are not passive – they are, in fact, active – in deciding whether and where to seek care. The following four assertions are the basis for this model [152].

The first three assertions have to do with the demand for health care. First, patients care more about health than health *care* and are only willing to pay for health care when they believe it will help them return to health. In this context, if a woman believes that having a skilled attendant present is likely to increase the probability of a good outcome, that is, that it will help keep her and her child healthy during delivery, she is likely to choose facility delivery.

Second, each illness or condition is different in the perceived necessary inputs that will result in health. Evidence suggests that patients seek out providers with better credentials when they have illnesses that are more complex to diagnose and treat [153]. In a maternal health context, this would mean that women who see childbirth as a particularly risky process or who see themselves as at risk may be willing to pay more or travel further for health care at a particular facility as compared to those who see childbirth as a simple, natural process and see themselves as being at low risk.

Third, patients cannot observe many of the key elements of health care and may rely on their perceptions to assess the level of inputs provided by a health care provider or facility. A woman who has heard from other women in her community that a particular provider does not treat patients well will be less likely to go to that facility.

The fourth assertion relates to the supply of health care provided at facilities, and states that larger facilities generally offer a standardized 'conveyor belt' approach to health care services with little regard for individual patient wants and needs. Smaller facilities or privately managed facilities may be able to be more responsive to those individual patient wants and needs. In this case patients may bypass their nearest health facility if they feel that another facility may be more responsive to their specific needs.

The active patient model hypothesizes that patient decision making about seeking health care is rational but complex, with multidimensional components that can be hard to measure. A search of the literature revealed no empirical tests of this model.

2.4.3 **Measurement**

Behavioral intention is typically measured through a direct question to an individual about what she intends to do in the future. In this study, the dependent variable of interest related to behavioral intention is intended delivery location. While the ideal outcome for this research

would have been actual delivery location, the available data are limited to using intended delivery location as a proxy.

While intention does not always predict actual behavior, in the case of facility delivery, it has been shown to be a good predictor. In a study in Ghana, 86.1% of women who were interviewed in antenatal care and who stated that they intended to deliver at a facility actually did [154]. A similar proportion (80.14%) was found in a 2015 study in Ethiopia [155].

Even more relevant for this study, the intention to deliver at a specific facility has been shown to be associated with delivery at that facility [156]. One study from Kenya showed that of 746 women who delivered in a health facility, 75.6% did so in their reported "preferred" place of delivery [157].

2.4.4 **Associations of quality of care and intended delivery location**

The interpersonal elements of quality of care have been shown to be associated with general care seeking intention [148, 158, 159], but evidence of associations of intended delivery location with any element of quality of care is limited. A study in Guatemala showed lower rates of intention for facility-based care for women who had poor interpersonal experiences during previous births [160]. Discrete choice experiments, a quantitative technique for eliciting preferences [161], in Africa have demonstrated that infrastructure as well as technical and interpersonal elements of quality were all significantly associated with a woman's intentions about where to deliver [146, 162]. Perceptions of facility infrastructure and interpersonal elements of the process of care in labor and delivery have been associated with intention to return to that particular health facility [163].

There is empirical evidence that women's perceptions of quality of care at earlier points along the maternal, newborn, and child continuum of care are associated with their actual care seeking behavior at later points. Low perceived quality of antenatal care has been associated with

late initiation of and an inadequate number (<4) of antenatal care visits [164-166]. High perceived quality of care has been associated with facility delivery [32, 157, 167-170].

Perceived quality of care has been associated not only with whether a woman receives a particular service along the continuum, but also her choice of the site of care. Several studies have observed that women bypass the nearest facility in order to deliver in a facility with a higher perceived level of quality [148, 151, 157, 171].

2.4.5 **Associations of patient satisfaction and subsequent health service utilization**

Patient satisfaction has been found to be related to continuing use of health care, maintenance of a relationship with a specific provider or health facility, and adherence to medical regimens [172-176]. In maternal health care, higher satisfaction may be related to a women's subsequent use of health care across the continuum of care [177].

2.4.6 **Other determinants of intended delivery location**

There is a limited evidence base on women's choice of a specific facility for delivery, however there is more literature covering a women's choice of facility delivery versus a home delivery. Therefore, this section will include literature on other non-quality of care determinants of the choice of delivery location – facility versus home.

2.4.6.1 *Community determinants*

Community norms have been identified as important determinants of the choice of facility delivery [32, 178, 179]. Higher percentages of community members who agree that facility delivery is important and who perceive better access to the nearest facility has been associated with higher rates of facility delivery [180, 181]. Evidence from a study from Tanzania points to the importance of community-perceived quality of care in the choice of facility – higher percentages of community members who agree that the local facility is "excellent" and that the doctors and nurses have good skills were associated with higher rates of facility delivery [180].

2.4.6.2 *Facility determinants*

Facility characteristics also influence a woman's choice of facility for delivery. Easier geographic access was associated with increased likelihood of facility delivery [32, 178]. Significant associations between cost of care and facility delivery have been found – with higher costs of care leading to lower rates of facility delivery [128, 135, 182, 183]. Location in urban areas has been associated with increased facility delivery rates in sub-Saharan Africa [184-186], although these differences may be modified by other community and individual level factors [187]. Associations between a facility's operating authority (private versus public) and facility delivery have also been identified but may be modified by other factors, such as household wealth and education [188].

2.4.6.3 *Individual determinants*

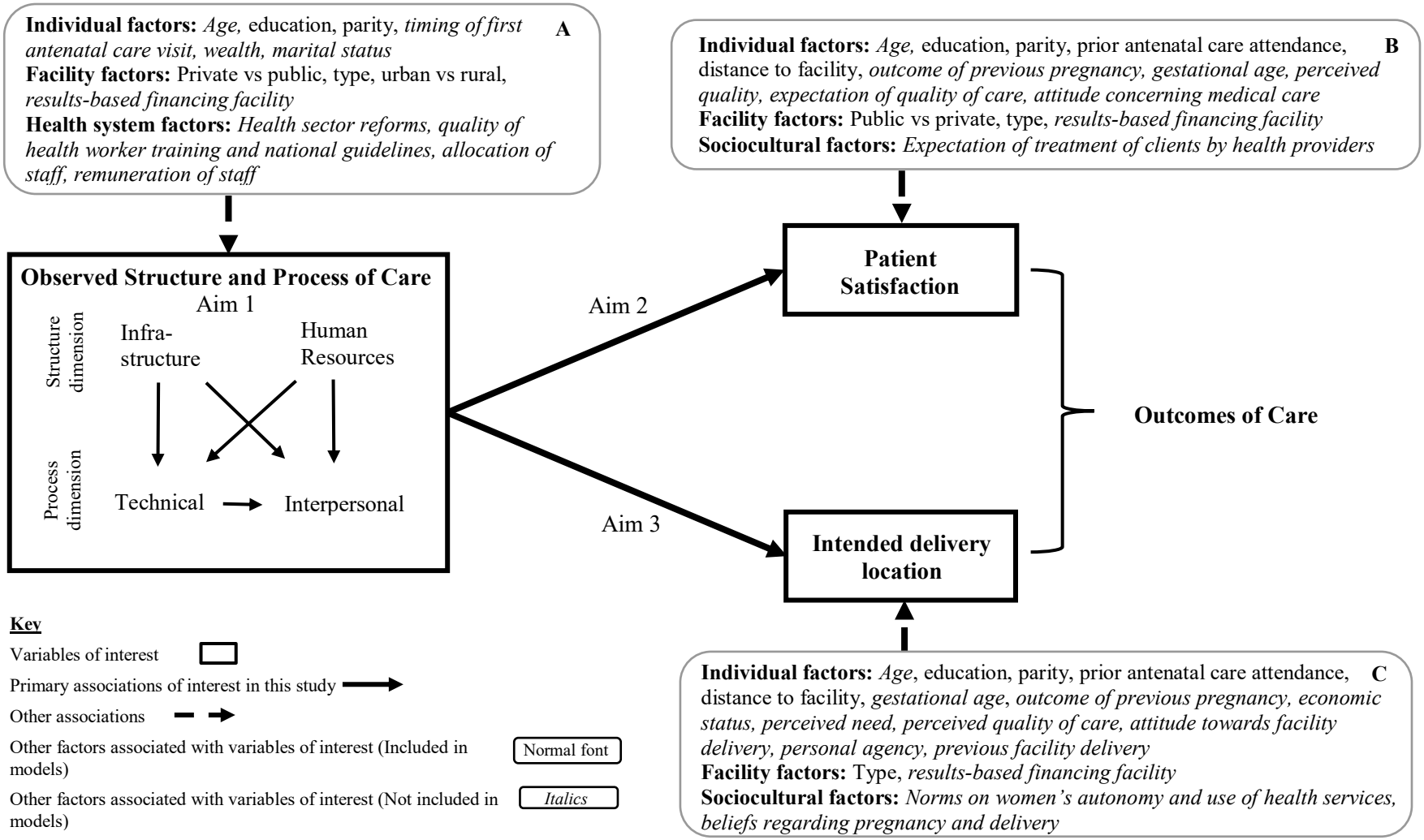
Higher education, frequent antenatal care utilization, and high level of autonomy in decision making have been found to be associated with facility delivery [188-193]. Women with a perceived need for facility-based delivery care have a higher likelihood of a facility delivery [178]. Previous childbirth experience is also a strong determinant of facility delivery, with the previous childbirth location generally predicting the location of subsequent deliveries [194, 195], however poor experience of previous facility delivery may lead to lower likelihood of facility delivery for subsequent deliveries [179, 196]. In the one study identified which assessed intention to delivery at a facility among pregnant women, the proportion of women who intended to deliver decreased with gestational age, although the difference was not tested statistically [60].

2.5 CONCEPTUAL FRAMEWORK

This study's conceptual framework was based on Donabedian's quality of care framework, which was described in detail earlier in this chapter. Additional models, theories, and evidence cited throughout this chapter informed the addition of covariates to the framework. The full conceptual framework is shown in Figure 2.3. The primary associations of interest for this study

are displayed in black solid arrows. The background section described the rationale for the hypothesized associations.

Figure 2.3: Conceptual framework



Prior research has identified many other variables outside of quality of care that are likely to influence associations between structure and process quality of care and outcomes. Boxes A – C list these variables. This study adjusted for those printed in plain text; factors that were not available in the dataset are in italics.

Box A lists facility and patient factors that have been linked to structure and process quality of care in previous literature, as discussed earlier in this chapter. In addition Parkhurst and colleagues used comparative analysis based on country case studies to identify health system factors essential to quality of maternal health care, including health sector reforms such as decentralization and privatization of services, as well as allocation of staff within the health care system [197]. Community engagement has been shown to be an effective tool to improve the infrastructure element of quality of care [198].

Box B displays the factors associated with patient satisfaction. These factors were identified from the evidence on individual and facility determinants of patient satisfaction discussed earlier in this chapter. In addition, Murphy's framework linking perceived quality of care with patient satisfaction, which was in turn linked with willingness to return for reproductive health services, informed information in Box B [199].

Box C shows the factors associated with intended delivery location. These factors were identified from the evidence on individual, facility, and community determinants of facility delivery discussed earlier in this chapter. In addition to Andersen's Behavioral Model of Health Services Utilization [140], discussed earlier, the Integrated Behavior Model informed the factors listed in Box C. The Integrated Behavior Model proposes attitude, perceived norms, and personal agency as the three components that directly affect intention of a health behavior [81].

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Chapter 3: Study Design and Methods

3.1 OVERVIEW

This chapter describes the study methods to evaluate the associations among structure and process quality variables in antenatal and labor and delivery care and the association of antenatal structure and process quality on the outcomes of patient satisfaction and intended delivery location. Section 3.2 describes the context of the study, followed by the study aims and hypotheses in Section 3.3. Sections 3.4 and 3.5 detail the study design and data sources. Section 3.6 describes the human subject approval received for this study. Section 3.7 presents the measurement approaches for the each of the key variables of interest as well as covariates. Finally, sections 3.8 and 3.9 describe the analytic sample and the analytic plan for each of the study aims, including statistical models.

3.2 STUDY CONTEXT

This research focused on maternal health services in Malawi. This section provides context by describing the scope of maternal and child health challenges in Malawi and describes the health system in which the health challenges are occuring.

Figure 3.1: Map of Malawi

Malawi is located in Southern Africa (See Figure 3.1.) with a population of over 17.3 million in country of less than 100,000 km^2. Over 80% of the population lives in rural areas, with the lower wealth quintiles over represented in the rural areas. Of the urban population, 75% is in the highest wealth quintile [1].

In 2000, the United Nations articulated eight Millenium Development Goals, a set of goals and targets to improve living conditions and meet the needs of the world's poorest. Nearly all (189) of the 193 UN member states signed on, including Malawi [2]. Two of the Millenium Development Goals (MDGs) are directly related to maternal and child health –MDG 4 (To reduce the under-five mortality rate by two thirds) and MDG 5 (To reduce the maternal mortality ratio by three quarters). Malawi achieved MDG 4 by decreasing under-five mortality from 245 deaths per 1000 live births in 1990 to 68 deaths by 2015 [3]. The country did not achieve MDG 5, although the country halved its maternal mortality ratio to 439 deaths per 100,000 births over the same period [1].

The most recent (2015-2016) Malawi Demographic and Health Survey revealed that 95% of pregnant women aged 15-49 received antenatal care from a skilled provider. Even so, only 24% initiated antenatal care in the first trimester and only 51% had four or more antenatal care visits, as recommended by the WHO [1]. Facility delivery rates were 91.4% [1]. Facility delivery rates increased from 53% in 2000 [4], likely related to a 2007 ban on deliveries with traditional birth attendants [5].

The government health sector accounts for about 60% of health services in the formal health sector, while Christian Health Association of Malawi (CHAM) facilities provide 37%, and private or NGO facilities account for 3% [6]. The government health sector staffs a range of primary community health posts and centers, district hospitals, and central hospitals. A Ministry of Health-defined Essential Health Package is offered free of charge through the public sector and agreements with CHAM and non-profit facilities [7]. The Essential Health Package includes the majority of priority reproductive, maternal, newborn, and child health (RMNCH) services. Malawi is heavily dependent on external funders, primarily the Global Fund for AIDS, Tuberculosis, and Malaria, the Department for International Development (United Kingdom), and the United States Agency for International Develoment (USA); these sources cover over half of total health expenditures [8].

Malawi has experienced a severe health human resource crisis due to high mortality from HIV/AIDS, lack of training programs, and emigration of skilled providers [9]. The number of health facilities[5] increased from 548 in 2003 to 613 in 2013 [6, 9], although the average number of hospital beds remains low at 1.3 beds per 1,000 population [10]. Recent assessments of quality of delivery care shows that the average facility only achieved 63% on a facility quality index (about 16 of 25 items). There were notable deficiencies in infrastructure, in line with previous research [11, 12].

3.3 Study Aims and Hypotheses

The study focused on quality of maternal health care, specifically antenatal and labor and delivery care, in Malawi. The aims and hypotheses were as follows.

[5] Does not include clinics and health posts.

Aim 1: Evaluate associations among four elements of facility quality of antenatal and labor and delivery care: two structure elements – infrastructure and human resources – and two process elements – technical and interpersonal.

Aim 1 focused on associations between structure and process elements in *both* antenatal and labor and delivery care.

Hypothesis 1.1: *Infrastructure is positively correlated with (a) technical and (b) interpersonal quality in both antenatal and labor and delivery care.*

Hypothesis 1.2: *Human resources are positively correlated with (a) technical and (b) interpersonal quality in both antenatal and labor and delivery care.*

There is support for these hypotheses from previous research. Qualitative research has shown that health workers believe that a lack of equipment, drugs, and other infrastructure, as well as poor human resources management adversely affect their ability to provide high quality of care [13]. Associations of human resources management with process quality of care are also supported by empirical evidence showing links of supportive supervision and job descriptions with improved technical process quality of care [14, 15]. Adequate infrastructure and supportive human resources management have also been shown to be positively associated with provider motivation, which may translate to higher interpersonal process quality [16, 17].

Hypothesis 1.3: *Labor and delivery technical quality is positively correlated with antenatal technical quality.*

Hypothesis 1.4: *Labor and delivery interpersonal quality is positively correlated with antenatal interpersonal quality.*

Although no empirical research on associations of process quality across different services in the same facility was identified in research for this dissertation, there is theoretical

support for these hypotheses. If infrastructure and human resources management are at least partial drivers of technical and interpersonal quality, as posited above, then it would follow that at a given facility, where infrastructure and human resources management should be relatively constant across service areas, technical and interpersonal quality should be positively correlated across antenatal and labor and delivery care.

Aim 2: Evaluate the association of facility structure and process quality of antenatal care with patient satisfaction with antenatal care.

Aim 2 focused on associations among structure, process, and outcome in *antenatal care only*.

> ***Hypothesis 2.1:*** *All four quality of care indices - infrastructure, human resources, technical, and interpersonal - are positively and directly associated with women's satisfaction with antenatal care received, after controlling for other covariates.*

As described earlier, previous studies have shown positive associations of infrastructure and human resources with patient satisfaction in diverse clinical settings [18-21]. While evidence of the association of patient satisfaction with technical quality is mixed, studies have shown either a positive [22-24] or null association [25-28]. The positive association hypothesized here was based on previous evidence of an association of observed quality of care with patient satisfaction in antenatal care in Malawi [22]. The association of patient satisfaction with interpersonal quality has been consistently positive [20, 21, 25, 29-32].

> ***Hypothesis 2.2:*** *The two process quality indices – technical and interpersonal – mediate the association of the two structural quality indices – infrastructure and human resources- with women's satisfaction with antenatal care received.*

As described earlier, studies which assessed the associations among structure, process, and outcomes have shown mixed findings [33-39]. However, partial mediation of the association of structure and outcomes through process was found in most studies [33-36, 39].

Aim 3: Evaluate the association of facility structure and process quality of antenatal care with patients' intended delivery location among women who attend antenatal care at a facility with labor and delivery care services.

Aim 3 focused on associations among structure, process, and outcome in *antenatal care only*.

Hypothesis 3.1: *All four quality of care indices - infrastructure, human resources, technical, and interpersonal - are positively and directly associated with intention to deliver at the same facility after controlling for other covariates.*

As described earlier, empirical evidence of associations of different elements of structural and process quality with future care seeking intention perceptions of facility infrastructure was limited. Where it existed, it pointed to positive direct associations between structural and process quality and future care seeking intention [40-42]. Previous research in Malawi has shown that women with a higher perceived quality of antenatal care have increased odds of using health care facilities during childbirth [43].

Hypothesis 3.2: *The two process quality indices – technical and interpersonal – mediate the association of the two structural quality indices – infrastructure and human resources – with intention to deliver at the same facility.*

Justification for this hypothesis is the same as for Hypothesis 2.2.

3.4 STUDY DESIGN

This was a cross-sectional study using existing data from the 2013-2014 Malawi Service Provision Assessment (SPA). In all Aims both patient and facility level data were used. However, in Aim 1 patient level data were aggregated to the facility level and a single level analysis was conducted, while Aims 2 and 3 used both facility and patient level data in a multilevel analysis.

3.5 DATA SOURCE

Malawi's SPA was a census of all Malawi's formal sector health facilities. The objective of the 2013-2014 SPA was to provide an overview of the health care environment, resources, and practices in formal sector health facilities in the country. Nearly all data collection instruments were based on generic instruments developed by the MEASURE DHS project, which implemented the assessment. The only exception was the labor and delivery observation tool, which was a Quality of Care assessment tool developed by the Maternal and Child Health Integrated Project (MCHIP) [44]. The instruments were adapted for Malawi in consultation with technical experts and stakeholders from the Malawi Ministry of Health. Exit interview questionnaires were translated into the two primary local languages, Chichewa and Tumbuka. A pre-test of the instruments and CAPI and CAFE programs was conducted prior to the roll-out of the assessment.

The SPA included the following components:

- The **Facility Inventory Questionnaire** measured the availability of services, infrastructure, supplies, medicines, staffing, training, and clinical procedures. This questionnaire was completed on tablets using computer-assisted personal interview (CAPI) technology. Latitude and longitude coordinates for each facility

were also collected. Data from this questionnaire were collected from all facilities able to be assessed.[6]

- The **Provider Interview Questionnaire** measured the experience, qualifications and perceptions of the service delivery environment among health care providers. Responses to this and all other data collection instruments were first recorded on paper and data were entered and edited immediately following data collection, while still in the facility. This mode of data collection is referred to as computer-assisted field editing (CAFE). Interviewers aimed to interview an average of eight providers in each facility. If a facility had fewer than eight providers, all providers present were interviewed. If a facility had more than eight providers, providers whose consultations were observed and those who provided information for any section of the Facility Inventory were targeted.
- The **Observation Protocols** for antenatal care, family planning, normal delivery, and sick child consultations assessed the extent to which providers adhered to accepted service delivery and quality standards. Interviewers were instructed to observe a maximum of five clients for each provider of the service, with a maximum of fifteen observations for antenatal care, family planning, normal delivery, and sick child consultations in any given facility.
- For all antenatal care, family planning, and sick child consultation patients whose care was observed, **Patient Exit Interviews** were also attempted, asking about their understanding of the services received, recall of instructions given, perceptions of how the services were delivered by the provider, and intended delivery location.

[6] Reasons for non-assessment were refusal (3%), facility had closed (2%), facility was inaccessible for some reason (2%), and no one available to respond to assessment (1%).

Eighty-six health care providers (nurses, nurse midwives, and clinicians) from the Ministry of Health were trained as interviewers over a three-week period. A sub-set (30) of interviewers with hands-on experience conducting normal deliveries and newborn care received additional training for the observation of normal deliveries and newborn care protocols.

Data collection took place in two phases: June-August 2013 and November-February 2014. During data collection, interviewers visited facilities in teams of three to four interviewers and a team leader. On average, data collection took one day per facility. Teams attempted to visit facilities on days with antenatal care, family planning, or sick child services would be offered, to facilitate the observation of such consultations. If one of those services was not being offered on the day of the visit, the team returned on another day to conduct the observations and interview clients. Teams with a member who had been trained in observation of delivery and newborn care were assigned to facilities known or likely to offer normal delivery services.

After completing data collection but before leaving a facility, the team would review the paper questionnaires and tablet Facility Inventory data. Paper questionnaires were entered into a second tablet computer. The team leader would then conduct consistency and structural checks to identify any errors or missing data. Once satisfied that the data collection and entry were completed, the data were sent to the central office using an Internet File Streaming Service. All paper questionnaires were sent by courier to the central office, where the data were entered again by separate data operators.

Additional detail on the data collection process can be found in the 2013-2014 Malawi SPA final report [9]. The 2013-2014 Malawi SPA dataset is publicly available upon request from the MEASURE DHS project website: https://dhsprogram.com/data/available-datasets.cfm.

3.6 HUMAN SUBJECTS APPROVAL

This study was a secondary data analysis of existing, publicly available data from the 2013-2014 Malawi Service Provision Assessment. The study was designated as not human subjects research by the Johns Hopkins Bloomberg School of Public Health Institutional Review Board (IRB) Office on March 7, 2018. (See Appendix E for IRB determination letter.)

3.7 MEASUREMENT

3.7.1 **Structure and process quality of care**

For this study, structure and process quality dimensions were broken down into component elements: infrastructure and human resources for structure, and technical and interpersonal for process. Each quality of care element was measured using an index, as done previously by researchers in developing quality of care measures using data from the SPA [12, 18, 45-47].

3.7.1.1 *Justification of using indices*

An index consists of a set of items whose independent causes may differ, but that collectively determine the level of a construct or variable [48]. Therefore, it is expected that each item of an index should theoretically relate to a single construct but with low inter-item correlation. An index can also be called a formative indicator. This is in contrast to a scale, where the underlying construct *causes* the values of the set of items. For a scale, also called a reflexive indicator, the assumption is that all of the items have a single, common cause [48]. In this study, indices rather than scales were created for each quality dimension. This determination was made based on the following criteria:

- Each quality element was seen as multi-dimensional. As will be described below, each index included items from multiple areas related to the particular element of quality.

- Items within each quality element measure were not anticipated to correlate with each other, as they were pulled from different areas of a quality element.
- Items within each quality element measure were seen as causing, rather than being caused by, the specific quality element.

These criteria indicated that indices were the more appropriate composite measure for this study [49-51].

3.7.1.2 *Item selection*

This section describes the item selection process in general. The following sections describe each step in the process as it related to the index measuring a specific quality of care element. Appendix A then provides the relevant tables with details of item identification and decisions regarding inclusion at each step in the process.

In index construction, selection or elimination of an item from the item pool must be theoretically justified rather than based purely on statistical properties, the exception being that items should vary and not be highly redundant, that is they should not be highly correlated with each other [49, 52, 53]. Therefore, the process of index construction was guided both by theory and by statistical criteria, according to the following steps:

- Identify potential items. For each quality element, potential items were identified from existing global standards from the World Health Organization (WHO), national standards from the Malawi Ministry of Health, and previously validated indices of quality [54-56].
- Compare potential items with items available in the SPA dataset. Potential items which were not available in the Malawi SPA were removed.
- Align potential items with SPA items. In some cases, multiple items in the SPA aligned with a single item in the list of potential items. In these cases, all the

items from the SPA were included. In other cases, a single item in the SPA was aligned with multiple items in the list of potential items. These items were resolved by determining where the SPA item would be most appropriate.

- Ensure items have content validity. The remaining potential items were then mapped to the quality elements and categories shown in Table 3.1. Any items which were more appropriate for other indices in this study were moved to the appropriate index.

Table 3.1: Categories of items for each quality of care dimension and element for antenatal and labor and delivery care

	Antenatal	Labor and Delivery
Structure		
Infrastructure		
1. Availability and functionality of water, energy, sanitation, hand-washing, and waste-disposal facilities	X	X
2. Work areas which facilitate the provision of services	X	X
3. Adequate stock of medicines, supplies, and equipment.	X	X
Human Resources		
1. 24-hour availability of at least one skilled birth attendant		X
2. Appropriate skills and competencies of health staff	X	X
3. Managerial and clinical leadership through meetings and quality assurance	X	X
Process		
Technical		
1. Evidence-based practices	X	X
2. Functional referral system	X	X
3. Information systems	X	X
Interpersonal		
1. Effective provider-patient communication	X	X
2. Patients treated with respect and dignity	X	X
3. Emotional support		X
Outcomes		
Patient Satisfaction	X	
Intended Delivery Location	X	

- Assess items based on statistical criteria. All items were coded to have dichotomous responses. Items that had low levels of missingness (<5%) and adequate variance in their response distribution (<96% on one response), and which were not highly correlated (≤.4) with other items within the same quality element were retained. When two items were highly correlated, each was compared against Malawi's national maternal health guidelines and existing indices of antenatal care and labor and delivery facility quality in LMIC [12, 18, 28, 45-47, 57]. If one item was mentioned in the Malawi guidelines and the other was not, the mentioned item was retained. If both items were mentioned in the Malawi guidelines, the item that appeared more often in other indices of quality was retained.

3.7.1.3 *Infrastructure quality indices*

Potential items for the infrastructure quality index were extracted from the WHO definitions of service readiness. The Service Availability and Readiness Assessment (SARA) lists the basic amenities and infection prevention materials necessary for all services, as well as the equipment, medicine, and diagnostics necessary for specific services. This study included those basic infrastructure items necessary for all services and those relevant for antenatal care and labor and delivery specifically. For content validity, the items were organized according to this study's definition of infrastructure as encompassing availability and functionality of water, energy, sanitation, hand-washing, and waste-disposal facilities; work areas which facilitate the provision of services; and adequate stock of medicines, supplies, and equipment.

3.7.1.3.1 Antenatal care

Thirty-two items relevant for antenatal care were identified from the SARA and of these, 30 (93.8%) were available in the SPA dataset's facility inventory questionnaire. Three of the 30 available items were more appropriate for other indices in the context of this study[7].

Data were complete or nearly complete for 26 of the remaining 27 items. One item – availability of a computer with internet access – was dropped because 8.8% of cases had missing data.

Of the remaining 26 items, 23 met the cut point for variability. Three items which were excluded because their response distributions did not meet the criterion of <96% in the more common response: availability of adequate sanitation facilities, availability of IPTp drug for malaria prevention, and availability of fetoscope.

Most correlations between pairs of the remaining 23 items were below the threshold[8]. Only four pairs of items had a phi coefficient (φ) above the cut-off of 0.4. For each pair, the two items were assessed and only one item was retained for inclusion in the final index. None of these items were specifically mentioned in the Malawi national antenatal care guidelines, so selection of the item to retain was based inclusion of each item in previous assessments of antenatal quality of care. For example, availability of a consultation table for antenatal care was perfectly correlated (φ=1) with availability of a standard precautions guide. In this case, the standard precautions guide was included in two of the six reviewed antenatal quality of care indices, while the consultation table was only included in one. Therefore, the standard precautions guide item was retained.

[7] Availability of emergency transport was included in the technical index, 24-hour availability of staff was included in the human resources index, and auditory and visual privacy was included in the interpersonal index.

[8] Phi (φ) is the appropriate correlation for two binary variables. Computing the Pearson's correlation coefficient for two binary variables will give the same value as phi.

Table 3.2 gives the final list of nineteen items included in the antenatal infrastructure index. The three categories within this index had five, five, and nine items, respectively.

Table 3.2: Final items of antenatal infrastructure quality of care index and their definitions

Final item	**Definition of item in SPA** *(Question number in SPA facility assessment in parentheses)*
1. Availability and functionality of water, energy, sanitation, hand-washing, and waste-disposal facilities	
Adequate power	Available electricity always available (340 and 341) or functional generator with fuel/charged battery (343 and 345 and 346)
Adequate communication systems	Available functioning phone (312 or 315) or short-wave radio (318)
Safe disposal of infectious waste available	ANC room has waste receptacle (1451.04)
Available disinfectant in ANC exam room	ANC room has disinfectant (1451.08)
Available soap and running water or alcohol-based hand rub in ANC exam room	ANC room has soap and running water (1451.01 and 1451.02) or alcohol-based hand rub (1451.03)
2. Work areas which facilitate the provision of services	
Standard precaution guidelines available	Observed available in ANC room (1451.13)
ANC guidelines available	Observed available in ANC room (1410)
Visual job aids available	Observed available visual aids for client education (1415)
At least 5 days/week of ANC service provided	ANC offered 5 days per week or more (1401)
Exam light available in ANC	Observed available and functioning exam light (421.04)
3. Adequate stock of medicines, supplies, and equipment.	
Latex gloves	Observed available (1451.07)
Blood pressure cuff/apparatus	Observed available and functioning (1421.01 or 1421.02)
Rapid hemoglobin test	Observed available and valid (1406.04)
Iron or folic acid or combination tablets	Observed available and valid (1422)
Tetanus toxoid vaccine	Observed available and valid (1422.04)
Insecticide treated bed nets	Observed available and valid (1422.06)
Scale	Observed available and functioning (1421.06)
Stethoscope	Observed available and functioning (1421.03)
Blank individual records available for ANC	Observed at least one blank copy of client health passport, health card, or record (1418)

ANC=antenatal care

3.7.1.3.2 Labor and delivery

Fifty-one items related to labor and delivery care infrastructure were identified from the SARA. Of those, 37 were available in the SPA data[9]. Four items were judged to be more appropriate for other quality of care domains and therefore were not included.

Data were complete or nearly complete for 32 of the 33 items. Availability of a computer with internet access surpassed the cut-off for missing data and was dropped. Four items had low variability with 98% or more on one response and were removed.

Of the remaining 28 items, four pairs, which included five total items, were correlated above the 0.4 cut-off. In each case, these redundancies were resolved by keeping the item that had a higher frequency of inclusion in previous labor and delivery quality of care measures. Three items were dropped.

Table 3.3 shows the final set of 25 labor and delivery infrastructure items. The three categories within this index had seven, three, and fifteen items, respectively.

[9] Twelve of the medications included on the SARA were included in the SPA but were not assessed for availability in the labor and delivery unit specifically.

Table 3.3: Final items for labor and delivery infrastructure index and their definitions

Final item	**Definition of item in SPA** *(Question number in SPA facility assessment in parentheses)*
1. Availability and functionality of water, energy, sanitation, hand-washing, and waste-disposal facilities	
Adequate power	Available electricity always available (340 and 341) or functional generator with fuel/charged battery (343 and 345 and 346)
Running water in ANC room	Visual confirmation in delivery room (1450.01)
Adequate communication systems	Available functioning phone (312 or 315) or short-wave radio (318)
Safe disposal of sharps available	Delivery room has sharps container (1651.06)
Safe disposal of infectious waste available	Delivery room has waste receptacle (1651.04)
Available disinfectant in delivery room	Delivery room has disinfectant (1651.08)
Available soap and running water or alcohol-based hand rub in delivery room	Delivery room has soap and running water (1651.01 and 1651.02) or alcohol-based hand rub (1651.03)
2. Work areas which facilitate the provision of services	
Standard precaution guidelines available	Observed available in delivery room (1651.13)
Labor and delivery guidelines available	Observed available guidelines for Integrated Management of pregnancy and childbirth in delivery room (1605 and 1606)
Exam light available in LD	Exam light observed available and functioning (flashlight is ok) (1622.03)
3. Adequate stock of medicines, supplies, and equipment.	
Delivery pack	Observed available (1623.02)
Suction apparatus	Observed available and functioning (1622.04)
Manual vacuum extractor	Observed available and functioning (1622.06)
Neonatal bag and mask	Observed available and functioning (1622.08)
Infant weighing scale	Observed available and functioning (1622.11)
BP apparatus	Observed available and functioning (1622.13 or 1622.14)
Antibiotic ointment for newborn	Observed available and valid (1625.01)
Injectable antibiotic	Observed available and valid (1625.02)
Injectable uterotonic	Observed available and valid (1625.03)
Injectable Magnesium Sulfate	Observed available and valid (1625.04)
Skin disinfectant (not chlorhexidine)	Observed available and valid (1625.07)
IV solution with infusion set	Observed available and valid (1625.06)
Stethoscope	Observed available and functioning (1622.15)
Incubator	Observed available and functioning (1622.01)
Chlorhexidine 4% gel or solution	Observed available and valid (1625.08)

3.7.1.4 *Human resources quality indices*

Potential items for the Human resources quality index were identified from the WHO quality of care framework for facility-based maternal and newborn care around the time of childbirth (hereafter referred to as the WHO QoC framework) [55, 56]. The WHO QoC framework includes "Competent, motivated human resources" as one of its eight domains of quality (See Figure 2.3). In this case, the input and process measures for the "Competent, motivated human resources" domain were used as potential items [58].

3.7.1.4.1 Antenatal care

Thirty-two items relevant for antenatal care were identified from the WHO QoC framework, and of these 12/32 (37.5%) were available in the SPA dataset. These items were from the facility inventory questionnaire and the provider interview. One of the items included in the SPA was only available combined with another question in the SPA dataset. Two potential items had multiple relevant items available in the SPA dataset – one had two relevant items, and one had three. For example, for the potential item of "Procedures and plans for recruitment, motivation, and retention of staff", three items in the SPA were relevant: existence of opportunities for promotion, receipt of salary supplements, and receipt of non-monetary incentives.

Of the fourteen remaining items, three had missing data. Of those only one was above the cut-off and was dropped. There were no items with 96% or greater on one response.

Correlations between pairs of the thirteen items were then assessed, with generally low correlations between items. Only one pair of items had a correlation coefficient above the cut-off: whether a provider had received any supervision in the past six months and whether a provider had received supervision with performance appraisal in the past six months. The item which was included in more previous quality of care indices – whether a provider had received any supervision in the past six months – was retained.

The final list of twelve items included in the antenatal human resources index is included in Table 3.4. The three categories within this index had one, seven, and four items, respectively.

Table 3.4: Final items for antenatal care human resources index and their definitions

Final item	**Definition of item in SPA** *(Question number in SPA health worker interview in parentheses)*
1. Availability of staff	
24-hour availability of staff	Is there a health care worker present at the facility at all times with an observed duty roster? (300/301/302) *
2. Appropriate skills and competencies of health staff	
Staff have received in-service training in last 2 years	Have health care providers received training or training updates on ANC topics in past 2 years? (502)
Procedures and plans for recruitment, motivation, and retention of staff	Are there any opportunities for promotion in your current job? (805)
	What type of salary supplement do you receive? (806)
	Do you receive any non-monetary incentives? (807)
Sufficient numbers of staff	Do available staff work an average of 40 hours or week? Calculated from the average number of hours per week worked (800)
Staff have a written job description	Do you have a written job description? (804)
Staff have received supervision in past 6 months	Do you receive technical support or supervision in your work? If so, how many times in the past six months? (801-802)
3. Managerial and clinical leadership through meetings and quality assurance	
Team meetings held to review competences and quality improvement activities	Does this facility routinely carry out quality assurance activities? If so, are there any official record of these activities? (440-441) *
Regular collection of patient and provider satisfaction data	Does this facility have any system for determining clients' opinions about the health facility or its services? (430) *
Meetings to review data, monitor quality improvement performance, make recommendations to address any identified problems	Does this facility have routine facility management meetings? (410) *
Meetings with stakeholders to review performance	Are there any routine meetings about facility activities with facility staff and community members? (417-418) *

*From facility assessment.

3.7.1.4.2 Labor and delivery

Thirty-two items relevant for labor and delivery human resources were identified from the WHO QoC framework, and closely related items were available in the SPA dataset for 12/32 (37.5%). Available items were from the facility inventory questionnaire and the provider interview. One of the items included in the SPA was only available combined with another question in the SPA dataset. Two potential items had multiple relevant items available in the SPA dataset – one had two relevant items, and one had three.

Of the fourteen items available in SPA, two had missing data, though neither approached the cut-off. There were no items with 96% or greater on one response.

Correlations between all pairs of remaining items were calculated, and only one pair of items had a correlation coefficient above the cut-off, supervision and supervision with performance appraisal. The item on any supervision in the past six months was retained as it was included in more previous quality of care indices.

Thirteen items were retained for the final index (See Table 3.5.). The three categories within this index had one, seven, and five items, respectively.

Table 3.5: Final items for labor and delivery human resources index and their definitions

Final item	**Definition of item in SPA** *(Question number in SPA health worker interview in parentheses)*
1. Availability of health staff	
24-hour availability of staff with on-duty roster	Is there a health care worker present at facility at all times with an observed duty roster? (300/301/302) *
2. Appropriate skills and competencies of health staff	
Staff have received in-service training in last 2 years	Have health care providers received training or training updates on Labor and Delivery topics in past 2 years? (502)
Procedures and plans for recruitment, motivation, and retention of staff	Do all delivery providers have opportunities for promotion in your current job? (805)
	Do all delivery providers receive a salary supplement? (806)
	Do all delivery providers receive any non-monetary incentives? (807)
Staff have received supervision in past 6 months	Do all delivery providers receive technical support or supervision in your work? If so, how many times in the past six months? (801-803)
Sufficient numbers of staff	Do providers on average work 40 or fewer hours per week? (800)
Staff have a written job description	Do all delivery providers have a written job description? (804)
3. Managerial and clinical leadership through meetings and quality assurance	
Quality improvement team	Does this facility routinely carry out quality assurance activities, are there any official record of these activities? (440-441) *
Regular collection of patient and provider satisfaction data	Does this facility have any system for determining clients' opinions about the health facility or its services? (430) *
Meetings to review data, monitor quality improvement performance, make recommendations to address any identified problems	Does this facility routinely conduct maternal and/or neonatal death audits? (1617) *
	Does this facility have routine facility management meetings? (410) *
Meetings with stakeholders to review performance	Are there any routine meetings about facility activities with facility staff and community members (417-418) *

*From facility assessment.

3.7.1.5 *Technical process quality indices*

3.7.1.5.1 Antenatal care

Potential items for the antenatal technical quality index were identified from the Malawi Ministry of Health guidelines on the content of focused antenatal care (FANC) visits [59, 60]. Items for each of these indices were grouped under evidence-based practices, functional referral systems, and information systems. There were no FANC items for functional referral systems and information systems and so items from the SPA were added to represent these two categories.

The initial list included 45 potential items, of which 44 were included in the SPA. Nineteen items related to counseling were considered to be more appropriate for the interpersonal index.

The item "Assessed client's history" was created as a composite of four items in the SPA. "Did the provider ask about the following: age, current medications, whether it is the client's first pregnancy, and date of last menstrual period." Assessment of seven significant symptoms of pregnancy complications (persistent cough, reduced fetal movement, bleeding, swelling, fever, fatigue, and headache/blurred vision) were combined into a composite item, "Did provider ask about any (at least one) of the seven significant symptoms". This choice was based on two factors. First, there was a lack of specificity in the Malawi FANC guidelines as to which complaints were to be asked about. Second, in the review of previous quality of care measures, out of the three instances where symptom assessment was included as an item, in two of the cases it was measured as "any" significant symptom assessment as opposed to measuring each individual symptom assessment.

Twenty items were therefore assessed for variability and missingness. Two of the remaining items had low variability. Over 99% of women had not received blood group testing nor received a urine test, therefore these items were removed. Correlations between pairs of the remaining eighteen items showed only two pairs of items that were correlated above the 0.4 cut-

off. Performance of or referral for a hemoglobin test and syphilis testing were correlated at φ=0.44 and checking a patient for edema and anemia were correlated at φ=0.50. Each pair of items was assessed and only one item was retained for inclusion in the final index based on the aforementioned decision rules.

The final list of items for the technical index included sixteen items: fourteen in the category of evidence-based practices, and one item each in the functional referral system and information systems categories. However, since there are different guidelines for the content of a first antenatal care visit as compared to a subsequent visit, three variants of the antenatal technical index were developed:

- First antenatal care visit includes fourteen total items: twelve evidence-based practices, and one item each in the functional referral system and information systems.
- Subsequent antenatal care visit includes eleven total items: nine evidence-based practices, one item each in the functional referral system and information systems.
- Any antenatal care visit includes nine total items: seven evidence-based practices, one item each in the functional referral system and information systems. These items are indicated with an x in both the “first” and “subsequent” relevant antenatal visit column in Table 3.6.

Table 3.6 shows all antenatal technical process items and indicates which are specific to the first visit, which are specific to subsequent visits, and which are common to both.

Table 3.6: Final items for antenatal technical process quality index and their definitions

Final item	Definition of item in SPA *(Question number in SPA antenatal observation in parentheses)*	Relevant antenatal visit	
		First	Subsequent
1. Evidence-based practices			
Takes client history	Observed provider asking questions on age, current medications, parity, LMP (104.01-104.04)	x	
Check weight	Observed done (107.02)	x	x
Check height	Observed done (107.12A)	x	
Check edema	Observed done (107.04)	x	x
Breast exam	Observed done (107.10)	x	x
Check fundal height	Observed done (107.07)	x	x
Check fetal heart beat	Observed done (107.08)		x
Blood pressure	Observed done (107.01)	x	x
Hemoglobin test	Performed or referred (108.01)	x	
HIV test	Performed or referred (109.04 or 109.05)	x	
Tetanus toxoid vaccination	Prescribed or given (112.01)	x	
Iron and folate	Prescribed or given (111.01)	x	x
IPTp	Prescribed or given (114.01 or 114.02)		x
Assess significant symptoms	Provider asked about or client mentioned at least one of these significant symptoms (106.01a-106.07a)	x	x
Persistent cough			
Fetal movement			
Vaginal bleeding			
Swollen hands or feet			
Fever			
Tiredness or breathlessness			
Headache or blurred vision			
2. Functional referral systems			
Emergency transport system	Functional ambulance with fuel observed * (450 and 453)	x	x
3. Information systems			
Functional system for collecting health services data	Does the facility have a system in place to regularly collect health services data and reports on it at least quarterly? * (460 and 461 and 462)	x	x

*From facility assessment.

3.7.1.5.2 Labor and delivery

Potential items for the labor and delivery technical index were taken from a previously validated index of labor and delivery technical quality [54]. In the labor and deliver observation instrument, there was a "don't know" option[10]. Items coded as "don't know" were recoded as missing. Of the nineteen items from the validated index, all were available in the SPA dataset. Two additional items were added based on the categories of "functional referral systems" and "information systems" being included within technical process quality.

Of the 21 potential items, one was removed due to low variability. Seventeen of the potential items had missing data, however, none were over the cut-off.

Pairs of the remaining twenty items were assessed for correlation. Checking a woman's HIV status and asking her if she had experienced vaginal bleeding were perfectly correlated ($\varphi=1$) and taking a woman's pulse and taking her blood pressure were also highly correlated ($\varphi=0.64$). Asking about vaginal bleeding and taking blood pressure were retained as they were included in more previous labor and delivery quality assessments.

The final list of eighteen items (See Table 3.7.) included sixteen items representing evidence-based practices, and one item each for the functional referral systems and information systems categories.

[10] There was no "don't know" option in the antenatal care observation instrument.

Table 3.7: Final items for labor and delivery technical process quality index and their definitions

Final item	**Definition of item in SPA** *(Question number in SPA labor and delivery observation in parentheses)*
1. Evidence-based practices	
Asks whether woman has experienced vaginal bleeding	Observed done (105.01)
Asks whether woman has experienced headaches or blurred vision	Observed done (105.03)
Takes woman's blood pressure	Observed done (116)
Washes hands before any examination of woman	Observed done (301)
Wears gloves for vaginal exam	Observed done (122)
Uses partograph	Observed done (206)
Prepares uterotonic for AMTSL	Observed done (223)
Prepares newborn bag and mask	Observed done (226 and 227 and 228)
Correctly administers uterotonic (1 min)	Observed done (312)
Assesses placenta and membranes for completeness	Observed done (321)
Assesses for perineal and vaginal lacerations	Observed done (322)
Kept baby skin-to-skin for 1 hour after birth	Observed done (416)
Ties or clamps cord when pulsations stop, or 2-3 minutes after birth	Observed done (407)
Takes mother's vital signs 15 minutes after birth	Observed done (412)
Palpates uterus 15 minutes after delivery of placenta	Observed done (413)
Assists mother to breastfeed within one hour	Observed done (417a)
2. Functional referral systems	
Emergency transport system	Functional ambulance with fuel observed (450 and 453) *
3. Information systems	
Functional system for collecting health services data	Does the facility have a system in place to regularly collect health services data and reports on it at least quarterly? (460 and 461 and 462) *

*From facility assessment.

3.7.1.6 *Interpersonal process quality indices*

Items for both the antenatal and labor and delivery interpersonal process quality index were derived from the WHO QoC framework. The WHO QoC framework domains of "Effective patient-provider communication" and "Patients treated with respect and dignity" were considered

as categories of antenatal interpersonal quality for the purposes of this study, with the addition of the "Emotional support" category for labor and delivery interpersonal quality. In this case, the input measures for each of these domains were extracted and used as an initial list of potential items [58].

3.7.1.6.1 Antenatal care

A total of ten potential items were derived from the WHO QoC framework. Of those, six were available in the SPA data. One of those items "All woman who attend antenatal care should receive written and verbal information and counselling" had four relevant items included in the SPA data. Of the nine relevant items, two were removed because of low variability. Only two of the remaining items had any missing data, but neither approached the cut off.

Correlations between the remaining seven items were evaluated, with no correlations approaching the cut-off. The final list of seven items included six items representing the effective provider-patient communication category, and one item representing the patients treated with respect and dignity category (See Table 3.8.).

Table 3.8: Final items for antenatal interpersonal process quality index and their definitions

Final item	**Definition of item in SPA** *(Question number in SPA antenatal observation in parentheses)*
1. Effective provider-patient communication	
All women who attend antenatal care should receive written and verbal information and counselling	Used visual aids (118)
	Counselled on importance of 4 ANC visits (110.03)
	Counselled on any danger signs (106.01b-106.07b)
	Counselled on at least 1 aspect of birth preparation (115.01-115.04)
All women who attend antenatal care are given the opportunity to discuss their concerns and preferences	Asked if client has any questions (117)
All health care staff in antenatal care demonstrate communication skills.	Informed patient about progress of pregnancy (110.02)
2. Patients treated with respect and dignity	
All women who attend antenatal care receive care in a private space	Visual and auditory privacy in ANC room (1452) *

*From facility assessment. Remaining items from patient-provider observation of antenatal care visit

3.7.1.6.2 Labor and delivery

Eighteen potential items for the labor and delivery interpersonal index were identified from the WHO QoC framework. Of these, twelve were represented in the SPA dataset. Two potential items were only available in combination with another item, one item was already included in the technical quality index and therefore ineligible to be included here, and one potential item had three relevant items in the SPA dataset. Therefore, twelve items were assessed for variability and missingness. All potential items had adequate variability and low missingness.

Only one pair of potential items were correlated above the 0.4 cutoff. These items, whether or not the provider explained the initial examination procedure to the woman or support person before proceeding, and whether or not the provider informed pregnant woman of findings

of the initial exam, were correlated at 0.41. The explanation of explained the initial examination procedure was retained as it was included in more previous quality of care assessments.

The final set of eleven items included five items representing the effective provider-patient communication category, three items representing the patients treated with respect and dignity category, and three items representing the emotional support category (See Table 3.9.).

Table 3.9: Final items for labor and delivery interpersonal process quality index and their definitions

Final item	**Definition of item in SPA** *(Question number in SPA labor and delivery observation in parentheses)*
1. Effective provider-patient communication	
All women in labor and delivery are given the opportunity to discuss their concerns and preferences	Asks if woman (or support person) has any questions (104.3)
All health care staff in labor and delivery demonstrate communication skills	Explains procedure to woman (support person) before proceeding with initial examination (113)
	At least once, explains what will happened in labor to woman during the first stage of labor (201)
	Explains procedures to woman or support person before proceeding with vaginal exam (215)
All women in labor and delivery should show good knowledge of the women's history and the care the care that had been given to date.	Checks client card or asks client her age, length of pregnancy, and parity (104.4)
2. Patients treated with respect and dignity	
All women are treated respectfully during labor and delivery	Any potentially harmful or inappropriate practices performed (603/604)
All women in labor and delivery receive care in a private space	Delivery space with visual and auditory privacy (1652) *
All women in labor and delivery receive respectful, non-discriminatory services	Provider respectfully greeted the woman (104.1)
3. Emotional support	
All women who gave birth in the health facility had a companion of their choice during labor and childbirth	Provider encourages woman to have a support person present during labor (104.02)
All women who give birth in the health facility were able to do so in the labor position of their choice.	At least once, provider encouraged/assists woman to ambulate and assume different positions during labor (203)
All women who give birth in the health facility report having sufficient food and drink during labor.	At least once, provider encourages woman to consume fluids/food during labor (202)

*From facility assessment. Remaining items from patient-provider observation of a delivery

3.7.1.7 *Index scoring*

Each final index was scored with an additive score, as has been used in previous quality of care indices [18, 22, 28, 45-47, 61], and each total score was divided by the number of

indicators to obtain an average to facilitate comparison of the indices. This approach has been recommended for creation of quality of care indices using the SPA data [62].

Measurement properties such as floor and ceiling effects of the resulting index scores were assessed. T-tests were used to compare the mean quality scores on the different indices for different relevant groups: urban vs rural facilities, hospitals vs health centers, and operating authority.

3.7.2 **Patient satisfaction**

The patient satisfaction outcome measure was created from women's responses to eleven questions regarding aspects of the antenatal care they received that day. For each of these eleven items, patients were asked to indicate whether it was a problem during their visit that day, and if so, whether it was a major or minor problem. In order to transform these data points into a satisfaction measure, each item was first reverse-coded, so that it represented a satisfaction scale rather than a problem scale. The "major problem" response was coded as "unsatisfied", "minor problem" as "more or less satisfied", and "no problem" as "satisfied". Then each item was dichotomized into satisfied vs. not satisfied, where not satisfied included any "unsatisfied" or "more or less satisfied" responses. These dichotomized responses were then added together to create a summative index with a possible range of 0-11, where a score of 0 would indicate a patient was not satisfied with any of the eleven aspects of care, and 11 would indicate a patient was satisfied with all eleven aspects of care. Table 3.10 presents the proportion of patients satisfied with each item in the patient satisfaction index as well as the mean and standard deviation of the overall patient satisfaction score.

Table 3.10: Distribution of patient satisfaction items and summative score

Item	N	Proportion satisfied with item (SD)
Ability to discuss problems or concerns about pregnancy	2038	0.92 (0.27)
Amount of explanation received about the problem or treatment	2041	0.95 (0.23)
Privacy from having others see the examination	2042	0.98 (0.16)
Privacy from having others hear your consultation discussion	2043	0.98 (0.15)
Availability of medicines at this facility	2007	0.88 (0.33)
Hours of service at this facility	2012	0.87 (0.33)
Number of days services are available to you	2011	0.93 (0.26)
Cleanliness of facility	2034	0.93 (0.25)
How the staff treated you	2043	0.95 (0.22)
Cost for services or treatment	1945	0.95 (0.23)
		Mean (SD)
Summative patient satisfaction score	2043	0.91 (0.14)

3.7.3 Intended delivery location

A binary measure of intended delivery location was created. Patients were asked the following question: "Have you decided where you will go for the delivery of your baby?", and if they answered "yes", their response was probed to determine the intended delivery location. Patients could choose the following responses: "This facility", "At other health facility", "Other location", and "Don't know/not decided". For this study, all "This facility" responses were coded "Yes" to indicate that the woman intends to deliver at the same facility where she received antenatal care, and all other responses were coded "No" to that the woman intends to deliver somewhere else.

3.7.4 Patient and facility characteristic covariates

Patient covariates included in the analysis were those available in the dataset and shown in previous research to be associated with patient satisfaction or choice of delivery location[11]. The

[11] Choice of delivery location (one facility vs another) is an infrequent outcome in previous studies. These covariates have been associated with facility delivery.

following patient covariates were included: first antenatal care visit [63, 64], education [22, 64-67], parity [64-67], and distance to facility [22, 40, 66].

Facility covariates included in the analysis were those available in the dataset and shown to be associated with patient satisfaction, choice of delivery location, or facility quality dimensions. The following facility covariates were included: operating authority, categorized as public versus private [18, 28, 45, 46, 68] , facility type, categorized as hospital versus health center [18, 28, 45, 68], and urbanicity, categorized as urban versus rural [66, 69]. In Aim 3, labor and delivery facility density was added as a facility level covariate [70]. Table 3.11 shows the covariates and the previously identified associations with variables of interest.

Table 3.11: Covariates for Aims 2 and 3 hypothesis testing and previous associations with primary variables of interest

	Patient satisfaction	**Facility delivery**	**Facility quality**[12]
Patient level			
First antenatal care visit	↑ as compared to subsequent visits [63, 64]	NA	NA
Education[13]	↓ with lower education [22, 64, 65]	↑ with higher education [66, 67]	NA
Parity[14]	↑ as parity ↑ [64, 65]	↓ with increasing parity [66, 67]	NA
Distance to facility	↓ at closer facilities [22]	↓ with increasing distance [66]	NA
Facility level			
Operating authority	↓at public facilities as compared to private [18, 28, 68]	NA	↓at public facilities as compared to private [45, 46]
Facility type	↓at health centers as compared to hospitals [68] ↑ at health centers as compared to hospitals [28]	NA	↓at health centers (Structural) [18] (general) [45] ↑ at health centers (Process) [18]
Urban location[15]	NA	↑ in urban settings [66]	↑ in urban settings [69]
Health facility density	NA	↑ with higher density of labor and delivery facilities [70]	NA

The following section details the preparation of each covariate for analysis.

[12] Measures of facility quality varied across studies. Studies are included here if they measured any aspect of facility quality (structural, process, general).

[13] In some studies, education is measured using reading level. In this study, it is measured using years of schooling. In this table, the two measures are combined.

[14] Although this may be due to selection bias. Multiparous women who are in ANC to be interviewed are more likely to have been satisfied with previous ANC and come back as compared to multiparous women who were not satisfied with previous ANC and did not return.

[15] In most studies, urban/rural designation was a patient characteristic. However, in the SPA dataset, urbanicity was available as a facility characteristic.

3.7.4.1 *First antenatal care visit*

The patient-provider observation included a count variable indicating the number of visits to this facility for this pregnancy. A binary variable was created to indicate whether a woman was at her first antenatal care visit.

3.7.4.2 *Education*

The patient-provider observation included a categorical variable indicating the highest level of education attended by the patient. Responses were “Never attended school”, “Primary”, Secondary”, and “Higher”. A binary variable was created to indicate whether a woman reported attending secondary school or higher.

3.7.4.3 *Parity*

Parity was assessed in the patient-provider observation using a binary variable to indicate whether this was the patient’s first pregnancy. Women pregnant for the first time were coded as “primiparous”, and others were coded as “multiparous”.

3.7.4.4 *Distance*

Patients were asked whether the facility was the nearest facility to their home, and responses were coded “yes” or “no”.

3.7.4.5 *Operating authority*

The operating authority of each facility was recorded in the facility inventory. A binary variable was created to indicate whether a facility was publicly or privately operated. The following responses were coded as “private”: Christian Health Association of Malawi, private for profit, mission/faith-based, NGO, and company. Facilities reporting government/public as their operating authority were coded as “public”.

3.7.4.6 *Health facility type*

The type of health facility was recorded in the facility inventory. A binary variable was created to indicate whether a facility was a hospital or a health center or below. Facilities were coded as "hospital" if their facility type included the word "hospital". Therefore central, district, rural/community hospitals and all other hospitals were grouped together. All other types of facilities, including those labelled as health center, maternity, dispensary, clinic, and health post, were coded as "health center".

3.7.4.7 *Urbanicity*

Urbanicity of each facility was recorded in the facility inventory as a binary variable, urban versus rural.

3.7.4.8 *Health facility density*

The health facility density variable was created using the latitude and longitude coordinates from the facility inventory. Using the coordinates of the 360 antenatal facilities also providing labor and delivery care, ArcGIS was used to create a 10-kilometer buffer around each facility. Previous research has indicated that 10 kilometers is a common distance to travel to a facility for delivery, and therefore was a reasonable distance within which to assess density of other possible delivery facilities [71]. A spatial join was then created joining the points of the GPS location of each facility with the 10-kilometer buffer. ArcGIS then provided a count of all labor and delivery facilities within that buffer. This value was used as the continuous health facility density variable.

3.8 SAMPLE

The 2013-2014 Malawi SPA was designed to be a census of all formal-sector[16] health facilities in the country. The Malawi Ministry of Health provided a master list of 1060 health facilities in the country. Of those, data were successfully collected from 977 (92%).

3.8.1 Aim 1 sample

In Aim 1, facility level data were used to describe the levels of and correlations among elements of antenatal and labor and delivery quality. Therefore, the sample was made up of facilities assessed in the SPA. Of the 977 facilities for which data were collected in the SPA, 643 provided antenatal care services and 540 provided labor and delivery services. Only a sub-set of facilities providing each type of service had complete data for the observations and patient exit interviews; some facilities offered antenatal services on the day of data collection, but no clients attended services. Additionally, only a sub-set of facilities had complete data on the provider interview. Table 3.12 provides details on the number and percentage of facilities contributing the different types of information.

Table 3.12: Number of facilities providing information, by type of service and data source

SPA Component of interest	Type of Service	
	Antenatal Care	Labor & Delivery Care
Facility Inventory Questionnaire	643 (100%)	540 (100%)
Observation Protocol and Patient Exit Interview	412 (64.1%)	221 (40.9%)[17]
Provider Interview Questionnaire	400 (62.2%)	219 (40.6%)
Completed all SPA components of interest	400 (62.2%)	219 (40.6%)
Included in sample	400 (62.2%)	197 (36.5%)[18]

[16] Formal-sector facilities are those facilities registered with the Central Monitoring and Evaluation Division of the Malawi Ministry of Health. Pharmacies and individual doctor's offices are not included.

[17] These facilities only had labor and delivery observations. Labor and delivery observations were not followed by patient exit interviews.

[18] Twenty-two facilities were removed from the labor and delivery sample because all of the delivery observations from that facility were incomplete. Fourteen were referrals to other facilities during the course of labor, one was a refusal during the course of labor, one was due to stillbirth, six were due to the need for newborn resuscitation.

3.8.2 Aims 2 and 3 samples

Analysis for Aims 2 and 3 was limited to antenatal care. Data for Aims 2 and 3 are two level, so there were two sample sizes of interest for the analyses: number of facilities (n) and total number of patients (N). Table 3.13 provides details on the sample sizes for both aims.

Table 3.13: Aim 2 and 3 sample sizes: Facility and patient

Antenatal Care Outcomes	Facilities	Patients
	n	N
Aim 2: Patient satisfaction	400	2043
Aim 3: Intended delivery location	360	1857

The 400 facilities in the Aim 2 sample were the sub-set of the 643 facilities providing antenatal care that provided complete data on all SPA components of interest for this study, as detailed in Table 3.12. Within these 400 facilities, 2043 patient-provider observations with paired patient exit interviews were conducted. The number of pairs of observations and interviews carried out at each facility ranged from 1 to 13 pairs, with a mean of 4.9 pairs per facility.

For Aim 3, any antenatal facilities which did not also provide labor and delivery care were excluded. It would not be appropriate to include those facilities in an analysis of whether or not women intended to deliver there. A total of 40 facilities were dropped, leaving 360 facilities in Aim 3 sample. The patient level sample size was also reduced (See Table 3.13.), reflecting the smaller number of facilities.

3.9 ANALYSIS

3.9.1 Aim 1: Evaluate associations among four elements of facility quality of antenatal and labor and delivery care: two structure elements – infrastructure and human resources -- and two process elements -- technical and interpersonal.

Hypothesis 1.1: *Infrastructure is positively correlated with (a) technical and (b) interpersonal quality in both antenatal and labor and delivery care.*

Hypothesis 1.2: *Human resources are positively correlated with (a) technical and (b) interpersonal quality in both antenatal and labor and delivery care.*

Hypothesis 1.3: *Labor and delivery technical quality is positively correlated with antenatal technical quality.*

Hypothesis 1.4: *Labor and delivery interpersonal quality is positively correlated with antenatal interpersonal quality.*

Step 1: Describe the infrastructure, human resource, technical, and interpersonal quality of care elements for antenatal care and labor and delivery.

Descriptive statistics were used to characterize each quality of care element, including mean, median, and standard deviations. Values for each index were visualized across subgroups (by Region, health facility type, public versus private, urban versus rural) using box plots. T-tests were used to explore subgroup differences in quality score. Each index was assessed for floor and ceiling effects.

Step 2: Determine the associations between antenatal structure and process quality of care indices, between labor and delivery structure and process quality of care indices, and between process quality of care indices in antenatal and labor and delivery care.

Pearson's correlations were initially planned to assess the strength of correlations among infrastructure, human resources, technical, and interpersonal quality of care indices. However, upon exploration of the validity of the assumptions necessary for Pearson's correlation[19], significant outliers were observed in over half of the quality measures. This violated the assumption of no significant outliers. Details of this analysis are presented in Chapter 4. Given

[19] Pearson's correlation is appropriate with the following assumptions: a linear relationship between the two variables, both variables are approximately normally distributed, and there are no significant outliers.

the presence of significant outliers, Spearman's correlation coefficients were calculated in Aim 1. The formula for Spearman's correlation coefficient is:

$$r_s = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)}$$

Where d_i is the difference of the ranked variables, and n is the sample size [72].

Technical and interpersonal quality indices were aggregated to the facility level and the facility average used in the correlation calculations. Correlations between quality elements within service type (*e.g*. association of technical and interpersonal quality in antenatal care) and across service type (*e.g*. association of infrastructure in antenatal care with infrastructure in labor and delivery care) were examined.

T-tests were used to test the statistical significance of the correlation coefficients, with a significance level of 0.05.

Aim 1 analysis was carried out in Stata.

3.9.1.1 *Sensitivity analyses*

As discussed in Chapter 2, when quality of care is measured using observations of patient-provider interactions, there is a risk of the Hawthorne effect, wherein providers change their behavior due to the presence of an outside observer. In order to account for this potential bias, the first sensitivity analysis assessed differences between average technical and interpersonal process quality score with and without the first observation for each observer.

The second sensitivity analysis explored whether the overall correlations between pairs of quality elements were sustained across different types of facilities, the correlations were compared for different groups of facilities: public versus privately managed facilities and hospitals versus health centers.

3.9.2 **Aim 2: Evaluate the association of facility structure and process quality of antenatal care with patient satisfaction with antenatal care.**

Hypothesis 2.1: *All four quality of care indices – infrastructure, human resources, technical, and interpersonal – are positively and directly associated with women's satisfaction with antenatal care received, after controlling for other covariates.*

Hypothesis 2.2: *The two process quality indices – technical and interpersonal – mediate the association of the two structural quality indices – infrastructure and human resources- with women's satisfaction with antenatal care received.*

Step 1: Exploratory data analysis

Exploratory data analysis was used to examine the distribution of all variables of interest, as well as to check for any irregularities or outliers. Mean and standard deviation of patient satisfaction and all continuous variables was described at patient and facility level. Proportions of all categorical measures were described at patient and facility level. Data was visually assessed using plots, first to show the relationship of each structure and process index with patient satisfaction at the patient level, and with subsequent plots partitioning the facility and patient level variation.

Using methods described by Kline [73], the unconditional intraclass correlation (ICC) (ρ) of patient satisfaction was calculated to verify that multilevel analysis was justified. The ICC explains the proportion of variance in a variable that is explained by the second (higher) level, in this case the facility level. The formula for the ICC (ρ) is shown by:

$$\rho = \frac{\sigma^2_{\mu_0}}{\sigma^2_{\mu_0} + \sigma^2_e}$$

where $\sigma^2_{\mu_0}$ is the facility level variance and $\sigma^2_{\mu_0} + \sigma^2_e$ is the total variance, the sum of the facility and patient level variance. Therefore, a high ICC would indicate that most of the variance observed in patient satisfaction are actually stemming from the facility variance. While there is no

universally agreed-upon cutoff, Kline suggests that if $\rho > .10$, the need for a multilevel approach is confirmed [73]. If $\rho \leq .10$, this indicates that most of the variance in the observed response stems from patient differences within facilities, and that an analysis approach accounting for the clustering is not warranted. Muthen also recommends calculating the design effect, $\rho(m - 1) + 1$ [74], where ρ is the ICC and m is the average number of patients per facility. Where the design effect is <2, a multilevel model is not necessary [75].

In this case, the ICC of patient satisfaction was 0.24, and the design effect was 2, therefore, a multilevel model was used.

Step 2: Bivariate analyses

Bivariate associations of patient satisfaction and the quality of care scores with facility and patient level characteristics were first assessed using t-tests. Additional bivariate associations of patient satisfaction with the quality of care measures were examined using simple linear regression and linear mixed models to account for clustering at the facility level.

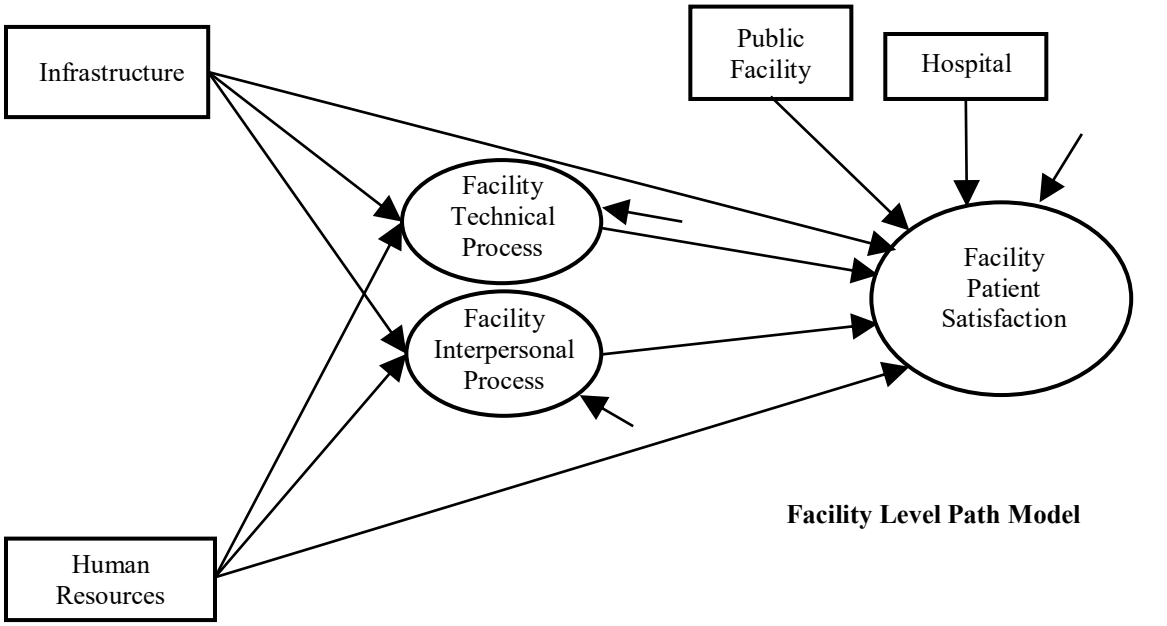
Step 3: Path analysis to test for associations

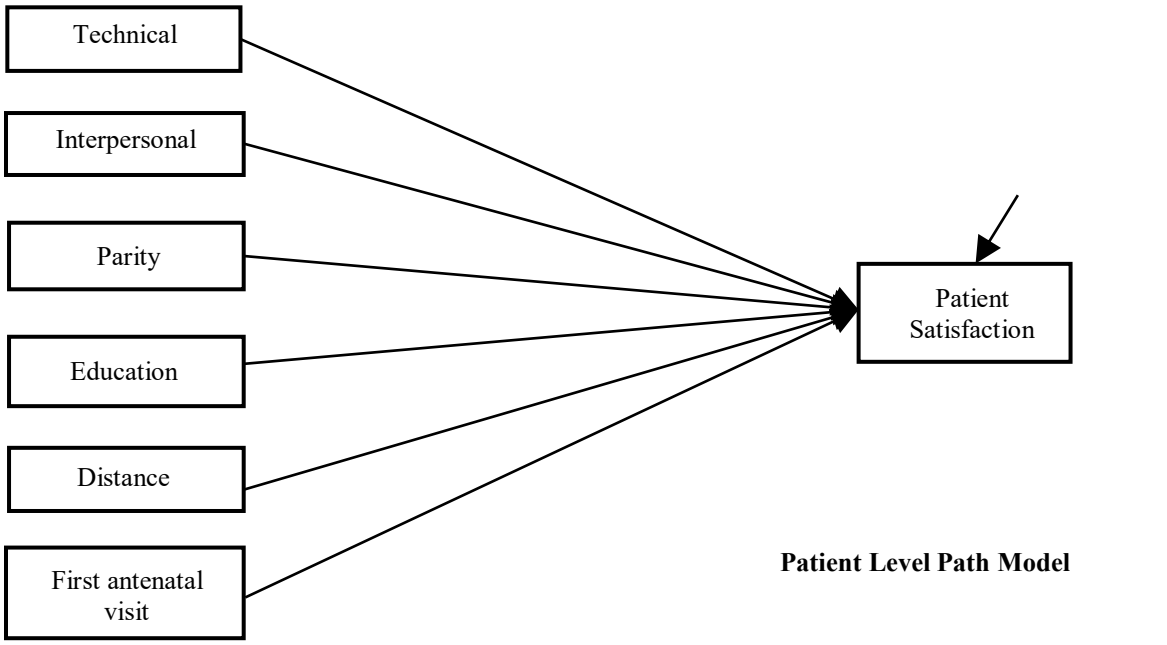
Path analysis is a structural equation modeling (SEM) approach used when there are only observed variables in a model. Unlike ordinary least squares regression, path analysis allows for simultaneous examination of associations among a system of variables and estimation of direct and indirect effects [73]. In this study, the path analysis approach allowed for concurrent testing for the direct and indirect effects of structure and process quality measures on patient satisfaction.

Path models are typically represented using path diagrams. Path diagrams representing the associations to be tested in Aim 2 are shown in Figure 3.3. In general path analysis notation, endogenous variables are variables that are determined by other variables in the model, also called dependent variables, while exogenous variables are not determined by other variables in the model, otherwise known as independent variables. Single headed arrows represent the

influence of one variable on another. Single headed arrows that point to an endogenous variable and which have no origin variable are residual arrows. Rectangles are used to indicate directly measured variables, and ovals or circles are used to represent variables that cannot be measured directly. In this case, when showing the technical process, interpersonal process, and patient satisfaction measures at the facility level, these variables are represented by circles since they were directly measured at the patient level [73].

Figure 3.2: Aim 2 path model





When using a SEM approach such as path analysis, a model must be assessed for "identifiability" to ensure that it is theoretically and mathematically possible to find a unique solution for all the parameters to be estimated [73]. Three rules are used to assess identifiability: the T-rule (necessary but not sufficient), the Null-B rule (sufficient but not necessary), and the Recursive rule (sufficient but not necessary). The models proposed here were identifiable based on the T-rule and the Recursive rule [71].

Multilevel path diagrams can also be represented by equations. The following section describes the series of equations which represent the path diagrams in Figure 3.2. This system of equations account for the nested structure of the data and the dependence of individual patients' responses within facilities that are estimated simultaneously (*e.g.,* level 1 and level 2 models).

Equation (1) corresponds to the patient level (level 1) model. The level 1 model includes the quality of care measures assessed at the patient level – technical and interpersonal process quality – as well as patient characteristics. Patient level variables are denoted with subscript_{ij}. The level 1 model is as follows:

(1) Level 1: $Y_{ij} = \pi_{0j} + \pi_1(Technical)_{ij} + \pi_2(Interpersonal)_{ij} + \pi_3(First\ Antenatal\ visit)_{ij} + \pi_4(Education)_{ij} + \pi_5(Parity)_{ij} + \pi_6(Distance)_{ij} + e_{ij}$

where Y_{ij} represents the patient satisfaction score for respondent *i* in facility *j*, and π_{0j} is the facility average patient satisfaction score. π_1 and π_2 are the effects of technical and interpersonal quality of the patient-provider interaction on patient satisfaction, respectively. π_3 is the difference in patient satisfaction between women attending their first antenatal care visit and those not at their first antenatal visit. π_4 is the difference in patient satisfaction between women who attended secondary school and those who did not attend secondary school. π_5 is the difference in patient satisfaction between primiparas and multiparous women. π_6 is the difference

in patient satisfaction between women attending antenatal care at the closest facility to home and women attending antenatal care not at the closest facility to home. e_{ij} is the level 1 residual error term that is assumed to be independently and normally distributed with a mean of zero and constant variance σ^2.

The facility, or level 2, model allows the intercepts from the level 1 model to vary randomly across facilities. In the level 2 equation, the facility average patient satisfaction score is regressed on the quality of care measures assessed at facility level – infrastructure and human resources – as well as facility average technical and interpersonal process quality measures and facility characteristics. Facility level variables are denoted with subscript_j. Equation (2) shows this model:

(2) Level 2: $\pi_{0j} = \beta_{00} + \beta_{01}(Technical)_j + \beta_{02}(Interpersonal)_j + \beta_{03}(Infrastructure)_j + \beta_{04}(Human\ Resources)_j + \beta_{05}(Public)_j + \beta_{06}(Hospital)_j + \mu_{0j}$

where β_{00} is the average patient satisfaction score of the outcome across all facilities; β_{01} and β_{02} are the change in the facility average patient satisfaction score in relation to the facility average technical and interpersonal process scores, respectively. β_{03} and β_{04} are the change in facility patient satisfaction score in relation to the infrastructure and human resources quality scores, respectively. β_{05} is the difference in facility patient satisfaction score between publicly and privately managed facilities. β_{06} is the difference in facility patient satisfaction score between hospitals and health centers. μ_{0j} is the between facility variance with a mean of zero and constant variance σ^2.

Figure 3.2 also shows that indirect effects of the structural elements of quality – infrastructure and human resources – on patient satisfaction are hypothesized through the process elements – technical and interpersonal – in the level 2 model. The two mediating variables are

measured at the patient level, however their mediation effect is hypothesized at the facility level. Therefore, the mediating variables must be decomposed into patient and facility level components in order to calculate the indirect effects. Equations 3-6 show how the technical and interpersonal process mediators are decomposed into the patient (Level 1) and facility (Level 2) components.

Technical process mediator:

(3) Level 1: $Technical_{ij} = \alpha_{T0j} + e_{Tij}$

(4) Level 2: $\alpha_{T0j} = \gamma_{T00} + \gamma_{T01}(Infrastructure)_j + \gamma_{T02}(Human\ Resources)_j + \mu_{T0j}$

Terms in equations 3 and 4 have subscript_T to indicate that they belong to the technical process mediator. Again, patient level variables are denoted with subscript_{ij}, and facility level variables are denoted with subscript_j.

Interpersonal process mediator:

(5) Level 1: $Interpersonal_{ij} = \alpha_{I0j} + e_{Iij}$

(6) Level 2: $\alpha_{I0j} = \gamma_{I00} + \gamma_{I01}(Infrastructure)_j + \gamma_{I02}(Human\ Resources)_j + \mu_{I0j}$

Terms in equations 5 and 6 have subscript_I to indicate that they belong to the interpersonal process mediator.

In equations 3 and 5, α_{T0j} and α_{I0j} are random intercepts, and e_{Tij} and e_{Iij} are level 1 residual terms. In equations 4 and 6, γ_{T00} and γ_{I00} are the fixed intercept means – the average facility technical and interpersonal score across all facilities; γ_{T01} and γ_{T02} are the change in the facility average technical score in relation to the infrastructure and human resources scores, respectively, while γ_{I01} and γ_{I02} are the change in the facility average interpersonal score in

relation to the infrastructure and human resources scores, respectively. Finally, μ_{T0j} and μ_{I0j} are level 2 residual error terms for the technical and interpersonal process mediators, respectively.

The indirect effects were calculated using the Sobel product of coefficients method, as recommended by Krull and MacKinnon [76] when seeking to calculate a separate estimate of multiple indirect effects.

(7) Indirect effect of infrastructure on patient satisfaction through technical process: $\gamma_{T01} * \beta_{01}$

(8) Indirect effect of infrastructure on patient satisfaction through interpersonal process: $\gamma_{I01} * \beta_{02}$

(9) Indirect effect of human resources on patient satisfaction through technical process: $\gamma_{T01} * \beta_{01}$

(10) Indirect effect of human resources on patient satisfaction through interpersonal process: $\gamma_{I01} * \beta_{02}$

Significance testing of these indirect effects was conducted using Monte Carlo confidence intervals, as recommended by Preacher and Selig [77]. The Sobel test, which is commonly used to test indirect effects, and which is calculated in Mplus, uses a z-test to test for significance of the indirect effect. However, z-tests assume that the indirect effects are normally distributed over repeated sampling, which is not true for the product of two normally distributed random variables in most circumstances [78, 79]. The Monte Carlo method makes no assumptions about the distribution of the indirect effect and therefore yields confidence intervals which are faithful to the skewed sampling distributions of indirect effects [77, 80].

Multiple goodness-of-fit measures that derive from different principles were assessed as recommended by Hox [81]. These included the model $\chi 2$ statistic, the root mean square error of approximation (RMSEA), the Bentler's Comparative Fit Index (CFI), and the standardized root

mean-squared residual (SRMR). These indices cover both absolute assessments of fit, which compare the predicted and the observed covariances (RMSEA and SRMR), and incremental assessments of fit, which compare the existing model fit with a null model with uncorrelated variables (CFI). Acceptable model fit was determined by a non-significant $\chi 2$ test, (CFI) values greater than .90, RMSEA values at or below 0.08, and SRMR values at or below .10 [73].

These goodness-of-fit measures were developed for single level models, and their application to multilevel models has certain drawbacks [82, 83]. First, the measures many not appropriately represent model fit at the facility level (level 2), since many of the goodness-of-fit statistics are sensitive to sample size and the sample size is typically much smaller at level 2. Second, single level goodness-of-fit measures cannot show whether problem with the fit are mainly at level 1, level 2, or both. Only the SRMR fit statistic has been adapted for multilevel models in Mplus and is reported for the level 1 and level 2 model separately. In general, there is limited evidence on appropriate goodness-of-fit measures in the multilevel context and researchers still commonly use the single level goodness-of fit measure for multilevel path analysis and SEM [84-86]. Therefore, multiple goodness-of-fit measures were estimated.

Exploratory data analysis and simple linear regressions for Aim 2 were carried out in Stata, and all mixed model analyses and multilevel path analyses were carried out in Mplus. A full-information maximum likelihood estimator with robust standard errors – the MLR estimator in Mplus – was used for this analysis, as recommended by Hox [87]. Sampling weights were applied to patients to account for their likelihood of being observed and interviewed among all the patients at the facility on the day of data collection.

3.9.2.1 *Sensitivity analyses*

Multiple sensitivity analyses were conducted to test the robustness of the results. Additional details on all sensitivity analyses conducted will be provided in Chapter 4.

First, all facilities with only one observation were dropped from the analysis and the analyses were rerun on this reduced sample. Having only one observation per facility limits the assessment of the within facility, or patient level, variation. For Aim 2, this reduced the sample to 1988 patients at 388 facilities.

Second, the first observation of each observer was removed to account for potential observer bias [88]. This further reduced the sample to 1564 patients at 386 facilities. The technical and interpersonal process quality scores were then re-calculated on the further reduced sample. The initial test to assess if the average observer's score was different with and without the first observation revealed that neither the technical nor interpersonal process quality score differed significantly without the first observation, there was no need to run the full models with the modified process quality scores.

The remaining sensitivity analyses were conducted on the full sample. Third, an analysis was conducted to compare the results of the coefficients of interest across different groups of facilities. The full path model was assessed on a sample which first separated out health centers and hospitals and then separated out publicly and privately managed health facilities.

Fourth, cross-level interactions of the significant facility and patient level covariates were added to the model to evaluate whether the associations at the facility level differ by patient characteristics.

3.9.2.2 *Power analysis*

There is no specific equation or across the board rule to determine the necessary sample size for the multilevel path models which were tested in this analysis. However, in instances where interest is at level 2, the facility level in the case of this study, at least 100 groups are recommended to detect small effects, while as few as 60 may be required to detect large effects.

[89, 90]. The hypotheses of this study are focused on the facility level associations, therefore, the existing sample of 400 facilities for Aim 2 should be sufficient.

A Monte Carlo simulation study was conducted to confirm adequate power for the parameters of interest with the available sample size and with the specific characteristics of this sample. Monte Carlo simulations allow the researcher to generate a large number of samples of the same size as the existing sample. These samples all reflect a population model, defined a priori based on previous evidence. The hypothesized model is then run on each of the samples, and the proportion of these runs in which the estimate is significant is the empirical power. This method has been recommended for multilevel structural equation model approaches where there is limited guidance on adequate sample size [91, 92].

In Aim 2, the associations between each facility level quality score and patient satisfaction were of primary interest. Therefore, the Monte Carlo simulation focused on those parameters. Since this was a secondary data analysis, the sample size was fixed to the existing sample size. Descriptive statistics of the sample were used as population variance parameters for the variables used in the model. The population effect sizes of the parameters of interest were hypothesized in two models.

The first model hypothesized medium size effects, using standardized effect sizes proposed by Cohen [93] and used by Raudenbusch and Liu [94] for multilevel models[20], of technical and interpersonal quality on patient satisfaction, with small effects of infrastructure and human resources on patient satisfaction. For the second model, the effect sizes were set conservatively low, with small effects of all four facility level quality covariates with patient satisfaction.

[20]These standardized effect sizes are: 0.2 represents a small effect, 0.5 represents a medium effect, and 0.8 represents a large effect.

Hypothesized effect sizes of all other facility and patient covariates were based on the findings of Aim 1 and the literature as discussed in Chapter 2 and were held constant for each model.

Each model was run on 1000 samples with the defined population parameters. Both simulations showed that the statistical power to detect all facility level associations of the quality covariates with patient satisfaction in both models with the given assumptions was above the recommended cut-off of 80% (See Table 3.14.).

Table 3.14: Power to detect a significant facility level association with patient satisfaction for each quality of care covariate using Monte Carlo simulation of two hypothesized effect sizes

	Infrastructure	**Human Resources**	**Technical**	**Interpersonal**
Model 1	1.00	1.00	1.00	1.00
Model 2	1.00	1.00	1.00	0.99

Model 1: Hypothesized an effect size of 0.2 for the facility level associations of infrastructure and human resources with patient satisfaction, and an effect size of 0.5 for the associations of technical and interpersonal quality with patient satisfaction. Other hypothesized facility level effect sizes are: 0.2 for facility level association of infrastructure on technical quality, 0.1 for infrastructure on technical quality, and 0.1 for human resources on technical and interpersonal quality. At the patient level, hypothesized effect sizes were: 0.2 for education, parity, distance, and first antenatal visit with patient satisfaction, and 0.5 for technical and interpersonal process quality with patient satisfaction.

Model 2: Hypothesized an effect size of 0.2 for the facility level associations of infrastructure, human resources, technical, and interpersonal quality with patient satisfaction. Other hypothesized facility level effect sizes are: 0.2 for facility level association of infrastructure on technical quality, 0.1 for infrastructure on technical quality, and 0.1 for human resources on technical and interpersonal quality. At the patient level, hypothesized effect sizes were: 0.2 for education, parity, distance, and first antenatal visit with patient satisfaction, and 0.5 for technical and interpersonal process quality with patient satisfaction.

3.9.3 Aim 3: Evaluate the association of facility structure and process quality of antenatal care with patients' intended delivery location among women who attend antenatal care at a facility with labor and delivery care services.

Hypothesis 3.1: *All four quality of care indices - infrastructure, human resources, technical, and interpersonal - are positively and directly associated with intention to deliver at the same facility after controlling for other covariates.*

Hypothesis 3.2: *The two process quality indices – technical and interpersonal – mediate the association of the two structural quality indices – infrastructure and human resources- with intention to deliver at the same facility.*

Step 1: Exploratory data analysis

Descriptive statistics, as previously described, were examined for each variable in the model. Plots were used to visualize the proportion of women who intend to deliver at the same facility where they attended antenatal care against each structural and process index, first overall, and then portioning the between and within variance. The ICC and design effect for the outcome were calculated. For binary outcomes the ICC is calculated as:

$$\rho = \frac{\sigma_{\mu_0}^2}{\sigma_{\mu_0}^2 + \frac{\pi^2}{3}}$$

where $\sigma_{\mu_0}^2$ is the facility level variance.

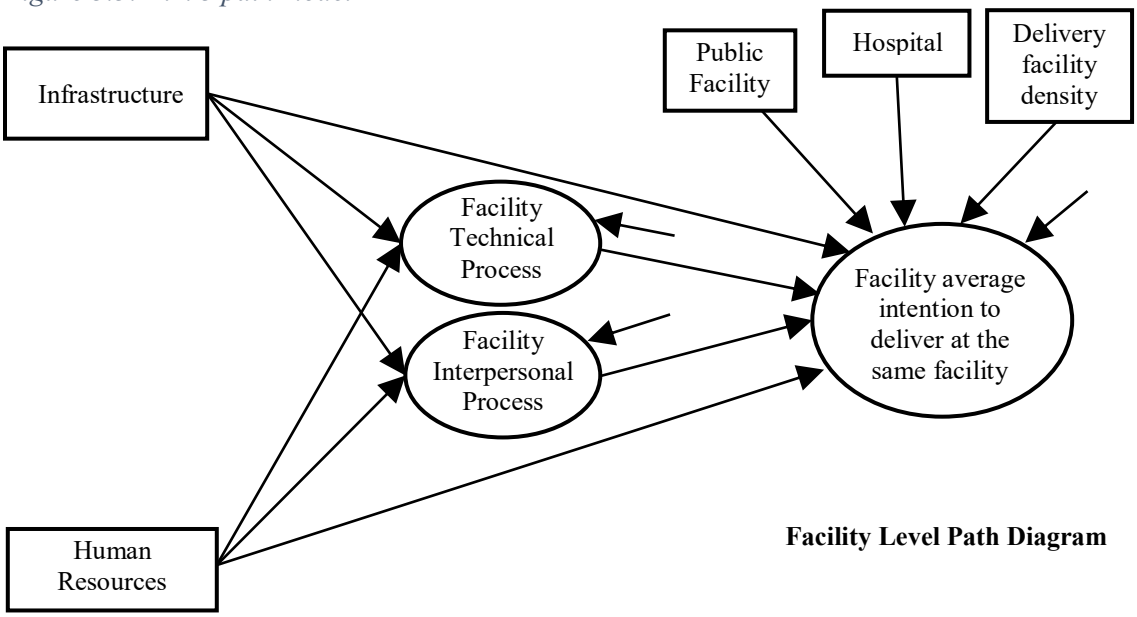
Step 2: Bivariate analyses

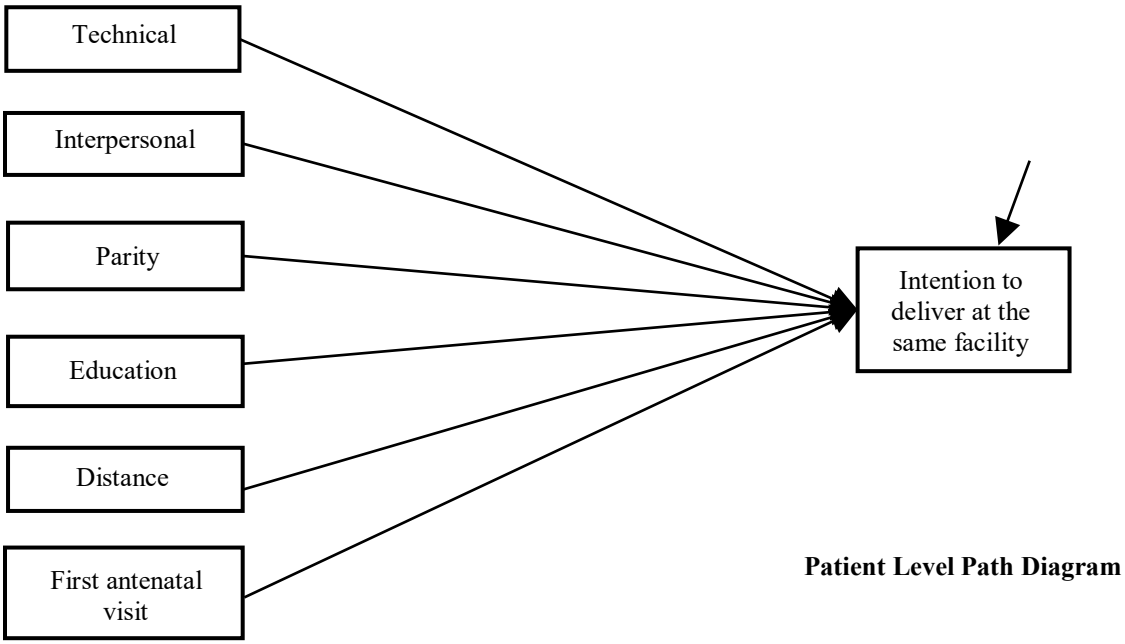
Bivariate associations of intention to deliver at the same facility with patient and facility characteristics were assessed using chi-square tests at the patient level, and t-tests for facility average proportion of women intending to deliver at the same facility. Bivariate associations of intention to deliver at the same facility with quality of care measures were evaluated using simple logistic regression and logistic mixed models to account for clustering at the facility level.

Step 3: Multilevel path analysis to test for associations

Following the steps described under Aim 2, the path model shown in Figure 3.3 was tested using path analysis.

Figure 3.3: Aim 3 path model





The multilevel path diagrams represented in Figure 3.3 can also be represented by equations. The following section describes the series of equations which represent those path diagrams. This system of equations account for the nested structure of the data and the dependence of individual patients' responses within facilities.

The level 1 model included the quality of care measures assessed at the patient level—technical and interpersonal process quality—as well as patient level characteristics. Intention to deliver at the same facility was a binary variable, therefore the response distribution uses a binomial distribution.

Equation (11) corresponds to the level 1 model (patients within facilities). Patient level variables are denoted with subscript_{ij}.

(11) Level 1:

Probability of intending to deliver at the same facility = P

$$\left(\log\left[\frac{P}{1-P}\right]\right)_{ij} = \pi_{0j} + \pi_1(Technical)_{ij} + \pi_2(Interpersonal)_{ij} + \pi_3(First\ Antenatal\ visit)_{ij} + \pi_4(Education)_{ij} + \pi_5(Parity)_{ij} + \pi_6(Distance)_{ij}$$

where $\left(\log\left[\frac{P}{1-P}\right]\right)_{ij}$ represents the log odds of a patient intending to deliver at the same facility for respondent *i* in facility *j*, and π_{0j} is the facility average proportion of patients who intend to deliver at the same facility. π_1 and π_2 are the effects of technical and interpersonal quality of the patient-provider interaction on the log odds of a patient intending to deliver at the same facility, respectively. π_3 is the difference in the log odds of a patient intending to deliver at the same facility between women attending their first antenatal care visit and those not at their first antenatal visit. π_4 is the difference the log odds of a patient intending to deliver at the same facility between women who attended secondary school and those who did not attend secondary

school. π_5 is the difference in the log odds of a patient intending to deliver at the same facility between primiparas and multiparous women. π_6 is the difference in the log odds of a patient intending to deliver at the same facility between women attending antenatal care at the closest facility to home and women attending antenatal care not at the closest facility to home.

The level 2 model for binary outcomes is the same as the level 2 model for continuous outcomes and allows the intercepts from the level 1 model to vary randomly across facilities. In the level 2 equation, the facility average proportion of patients who intend to deliver at the same facility is regressed on the quality of care measures assessed at facility level – infrastructure and human resources—as well as facility average technical and interpersonal process quality measures and facility characteristics. Facility level variables are denoted with subscript_j. Equation (12) shows this model:

$$\begin{aligned}(12) \quad \text{Level 2: } \pi_{0j} = {} & \beta_{00} + \beta_{01}(Technical)_j + \beta_{02}(Interpersonal)_j + \\ & \beta_{03}(Infrastructure)_j + \beta_{04}(Human\ Resources)_j + \beta_{05}(Public)_j + \\ & \beta_{06}(Hospital)_j + \mu_{0j}\end{aligned}$$

where β_{00} is the overall average proportion of patients who intend to deliver at the same facility; β_{01} and β_{02} are the change in the facility average proportion of patients who intend to deliver at the same facility in relation to the facility average technical and interpersonal process scores, respectively. β_{03} and β_{04} are the change in facility proportion of patients who intend to deliver at the same facility in relation to the infrastructure and human resources quality scores, respectively. β_{05} is the difference in facility proportion of patients who intend to deliver at the same facility between publicly and privately managed facilities. β_{06} is the difference in facility proportion of patients who intend to deliver at the same facility between hospitals and health centers. μ_{0j} is the between facility variance with a mean of zero and constant variance σ^2.

Equations for the mediating variables were the same as equations 3-6 and calculations for the indirect effects were the same as equations 7-10 in section 3.9.2.

Exploratory data analysis for Aim 3 was carried out in Stata, and path analysis was carried out in Mplus. A full information maximum likelihood estimator with robust standard errors and a logit link was used, taking into account the binary nature of the outcome variable. Goodness of fit statistics are not available for the maximum likelihood estimator with a logit link in Mplus and so were not reported for this model. Sampling weights were applied to patients to account for their likelihood of being observed and interviewed among all the patients at the facility.

3.9.3.1 *Sensitivity analyses*

As described in section 3.9.2.1, multiple sensitivity analyses were conducted to test the robustness of the results.

The first sensitivity analysis involved dropping facilities where there was only one observation. For Aim 3, this reduced the sample to 1810 patients at 353 facilities.

The second sensitivity analysis involved dropping the first observations at the remaining facilities to explore if the Hawthorne effect biased the performance of providers during the first observation. This further reduced the sample to 1452 patients at 351 facilities. As with Aim 2, when the first observations of each observer were dropped, neither the technical nor interpersonal process quality score differed significantly without the first observation, therefore there was no need to run the full models with the modified process quality scores.

The remaining sensitivity analyses were conducted on the full sample. The third sensitivity analysis conducted was to compare the results of the coefficients of interest between groups. The model was assessed on a sample which first separated out health centers and hospitals and then separated out publicly and privately managed health facilities.

The final sensitivity analysis added cross-level interactions of the significant facility and patient level covariates to the model to evaluate whether associations at the facility level differ by patient characteristics.

3.9.3.2 *Power analysis*

The available sample size of 360 facilities meets the rule of thumb criteria for at least 100 level 2 units – facilities – since our interest is in parameters at the facility level [89].

This was tested empirically with a Monte Carlo simulation study. A description of the Monte Carlo process can be found in section 3.9.2.1.

In Aim 3, the associations of each facility level quality score with facility average intention to deliver at the same facility were of primary interest. Power to detect these hypothesized effects sizes was tested with two models. In each model, the sample size was fixed to the existing sample size and descriptive statistics of the sample were used as population mean and variance parameters for the variables used in the model.

The first model hypothesized medium size effects, using standardized effect sizes proposed by Cohen [93] and used by Raudenbusch and Liu [94] for multilevel models[21], of all facility level quality of care elements on intention to deliver at the same facility. For the second model, the effect sizes were set conservatively low, with small effects of all facility level quality covariates with patient satisfaction. Hypothesized effect sizes of all other facility and patient covariates were based on the findings of Aim 1 and the literature as discussed in Chapter 2 and were held constant for each model.

[21]These standardized effect sizes are: 0.2 represents a small effect, 0.5 represents a medium effect, and 0.8 represents a large effect.

Each model was run on 1000 samples with the defined population parameters. These simulations showed that the statistical power for the all parameters in both Model 1 and Model 2 was at or above the 80% threshold (See Table 3.15.).

Table 3.15: Power to detect a significant facility level association with intention to deliver at the same facility for each quality of care covariate using Monte Carlo simulation of two hypothesized effect sizes

	Infrastructure	**Human Resources**	**Technical**	**Interpersonal**
Model 1	1.00	1.00	1.00	1.00
Model 2	0.80	0.84	0.83	0.86

Model 1: Hypothesizes an effect size of 0.5 for technical process, interpersonal process, infrastructure, and human resources on intention to deliver at the same facility. Other facility level effect sizes were: 0.5 of facility type, 0.2 of operating authority on intention to deliver at the same facility, 0.2 for facility level association of infrastructure on technical quality, 0.1 for infrastructure and human resources on interpersonal quality. Patient level effect sizes were: log odds of -0.4 for education, 0 for first antenatal visit and technical process quality, and 0.4 for parity, distance, and interpersonal process quality with intention to deliver at the same facility.

Model 2: Hypothesizes an effect size of 0.2 for technical process, interpersonal process, infrastructure, and human resources on intention to deliver at the same facility. Other facility level effect sizes were: 0.5 of facility type, 0.2 of operating authority on intention to deliver at the same facility, 0.2 for facility level association of infrastructure on technical quality, 0.1 for infrastructure and human resources on interpersonal quality. Patient level effect sizes were: log odds of -0.4 for education, 0 for first antenatal visit and technical process quality, and 0.4 for parity, distance, and interpersonal process quality with intention to deliver at the same facility.

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Chapter 4: Results

4.1 OVERVIEW

This chapter describes the findings of the study by aim. The sub-section for each aim begins with a description of the study sample, followed by univariate and bivariate distributions of the quality of care measures in the sample. Next, results from the main analyses are presented, followed by the results from sensitivity analyses.

4.2 AIM 1

Aim 1 was to evaluate associations among four elements of facility quality of antenatal and labor and delivery care: two structure elements – infrastructure and human resources – and two process elements – technical and interpersonal.

4.2.1 **Sample**

Aim 1 uses the quality variables aggregated to the facility level, so the sample is of facilities.

The 2013 Malawi Service Provision Assessment was a census of all 1060 health facilities in Malawi. Data were successfully collected from 977 (92%) of those. Of this sample of 977, 643 (65.8%) provided antenatal care and of these 400 (62.2%) had complete data on all SPA components of interest necessary for completion of the antenatal quality indices. Of these 977 facilities, 540 (55.3%) provided labor and delivery care and of these 540 facilities, 197 (36.5%) had complete data on all SPA components of interest necessary for completion of the labor and delivery quality indices. Table 4.1 provides an overview of how facilities included in the sample differ from the population of facilities providing antenatal and labor and deliver services. Data from the facility assessment at those facilities with complete data were used to develop the facility level infrastructure and human resources quality scores.

Table 4.1: Percent distribution of facilities included and not included in analyses

	Facilities which offer antenatal services				**Facilities which offer normal labor and delivery services**		
	Not in sample n = 243	In the sample n = 400	p-value		Not in sample n = 343	In the sample n = 197	p-value
Region							
North	24.3	15.0	**<0.01**		22.5	13.2	**<0.05**
Central	29.6	41.8			34.4	43.2	
South	46.1	43.2			43.1	43.6	
Facility type							
Hospital	8.2	21.5	**<0.001**		9.9	32.5	**<0.001**
Health Center	91.8	78.5			90.1	67.5	
Operating Authority							
Public	58.4	66.5	**<0.05**		64.4	68.5	0.33
Private	41.6	33.5			35.6	31.5	
Urbanicity							
Urban	19.8	17.3	0.43		11.4	20.8	**<0.01**
Rural	80.2	82.7			88.6	79.2	

Bold p-value indicates significant difference by chi-square test

Data from observations of provider-patient interactions was used to develop scores of antenatal technical and interpersonal process quality, as described in Chapter 3. Overall, a total of 2043 antenatal visits were observed across the 400 facilities for an average of five observed visits per facility. The range in observed visits was 1 – 13. A total of 388 observations of deliveries at 197 facilities were used to develop the facility level measures of labor and delivery technical and interpersonal process quality. Each facility had an average of two labor and delivery observations, with a range of 1 – 11.

Table 4.2 shows characteristics of the facilities in the Aim 1 sample. A small proportion of the facilities across all aims were located in the Northern Region, with the remainder split relatively evenly over the other two Regions. Over three-quarters of antenatal facilities were

health centers or below[22], while just over two-thirds of labor and delivery facilities were health centers. The majority of facilities were public and located in rural areas.

Table 4.2: Descriptive characteristics of 400 antenatal and 197 labor and delivery facilities in the Aim 1 study sample

	Antenatal facilities		**Labor and delivery facilities**	
	n	%	n	%
Region				
North	60	15.0	26	13.2
Central	167	41.8	85	43.2
South	173	43.2	86	43.7
Facility type				
Health Center	314	78.5	133	67.5
Hospital	86	21.5	64	32.5
Operating Authority				
Private	134	33.5	62	31.5
Public	266	66.5	135	68.5
Urbanicity				
Urban	69	17.2	41	20.8
Rural	331	82.8	156	79.2

4.2.2 **Quality of care**

4.2.2.1 *Antenatal care*

The four facility level antenatal quality scores ranged from 0.43 to 0.57 (See Table 4.3.). These scores represent the average proportion of quality items within a facility. For example, the antenatal infrastructure quality score of 0.57 (SD: 0.16) indicates that on average the 400 facilities had 57% of the nineteen recommended infrastructure items.

[22] Facilities below health center level included maternities (n=1), dispensaries (n=7), clinics (n=18), and health posts (n=1). The overwhelming majority were health centers (n=287), so "health centers" will be used to refer to this group.

Table 4.3: Facility level mean and standard deviation of antenatal quality measures across the 400 antenatal facilities

Antenatal quality of care at facilities	Infrastructure	Human resources	Technical	Interpersonal
Number of items in measure	19	12	9	7
Range	0-1			
Overall	0.57 (0.16)	0.43 (0.14)	0.49 (0.16)	0.55 (0.16)
Operating authority				
Public	**0.55 (0.15)**	0.42 (0.13)	**0.47 (0.16)**	0.55 (0.17)
Private	**0.61 (0.16)**	0.44 (0.14)	**0.54 (0.17)**	0.55 (0.16)
Facility type				
Hospitals	**0.68 (0.16)**	**0.50 (0.14)**	**0.57 (0.17)**	0.55 (0.13)
Health center	**0.54 (0.14)**	**0.41 (0.13**	**0.47 (0.16)**	0.55 (0.17)
Urbanicity				
Urban	**0.64 (0.16)**	**0.46 (0.14)**	**0.56 (0.17)**	0.57 (0.15)
Rural	**0.55 (0.15)**	**0.42 (0.14)**	**0.48 (0.16)**	0.54 (0.17)

Bold indicates significant difference on t-test of means

Privately operated facilities had higher infrastructure quality and technical quality scores as compared to public facilities (infrastructure: t (398) = 4.01, p<0.001, technical: t (398) = 4.42, p<0.001). Hospitals had higher infrastructure, human resources, and technical quality scores as compared to health centers (infrastructure: t (398) = -8.00, p<0.001, human resources: t (398) = -5.58, p<0.001, technical: t (398) = -5.04, p<0.001). Facilities located in urban areas also consistently scored higher as compared with rural facilities (infrastructure: t (398) = -4.52, p<0.001, human resources: t (398) = -2.37, p=0.02, technical: t (398) = -3.82, p<0.001).

T-tests were also used to explore differences for specific items in each quality index for the different facility characteristics – private versus public, hospital versus health center, and urban versus rural. Public-private facility differences were driven by significant differences in seven of the nineteen infrastructure items and four of the nine technical items[23]. Hospital-health

[23] For any antenatal visit. There were significant differences in seven of the fourteen items for a first antenatal visit, and five of the eleven items for a subsequent antenatal visit.

center differences were driven by differences in ten of the nineteen items infrastructure items, five of the twelve human resources items, and six of the nine technical items[24]. Urban-rural differences were driven by differences in nine of the nineteen infrastructure items, four of the twelve human resources items, and four of the nine technical items[25]. Appendix B shows the results of this analysis for each antenatal quality index.

4.2.2.2 *Floor/ceiling effects*

Each quality of care index was assessed for floor and ceiling effects by calculating the percentage frequency of the lowest (floor) or highest (ceiling) possible score. The lowest possible score on all indices was zero, while the highest possible score was one. Facility level quality variables were assessed at the facility level, while patient level quality variables were assessed at both the patient and facility level. Floor or ceiling effects are defined as 15% (or more) at the lowest or highest score [1, 2]. Results in Table 4.4 demonstrate that there were no floor or ceiling effects observed in the antenatal quality of care measures.

Table 4.4: Floor and ceiling effects in facility level antenatal quality of care indices among 400 facilities

	Infrastructure	**Human Resources**	**Technical**	**Interpersonal**
Ceiling	1 (0.3%)	0 (0.0%)	2 (0.5%)	15 (3.8%)
Floor	0 (0.0%)	1 (0.3%)	6 (1.5%)	1 (0.3%)

Ceiling = Score of 1, Floor = Score of 0

4.2.2.3 *Labor and delivery care*

All labor and delivery quality scores ranged between 0.44 and 0.69. Just as in antenatal care, the scores could range from 0-1 and represent the average proportion of items present. The infrastructure quality score was 0.69 (SD: 0.13). This means that on average the 197 facilities had

[24] For any antenatal visit. There were significant differences in seven of the fourteen items for a first antenatal visit, and seven of the eleven items for a subsequent antenatal visit.

[25] For any antenatal visit. There were significant differences in seven of the fourteen items for a first antenatal visit, and five of the eleven items for a subsequent antenatal visit.

69% of the twenty-five recommended infrastructure items. The human resources quality score was 0.44 (SD: 0.15), the technical process quality score was 0.58 (SD: 0.12), and the interpersonal process quality score was 0.67 (SD: 0.15).

The patterns of quality scores across facility characteristics for labor and delivery facilities was similar to antenatal care facilities (See Table 4.5.). Privately operated facilities had higher infrastructure and technical quality scores as compared to public facilities (infrastructure: t (195) = 2.09, p=0.04, technical: t (195) = 2.66, p<0.01). Hospitals had higher infrastructure, and human resources, and technical quality scores as compared to health centers (infrastructure: t (195) = -7.96, p<0.01, human resources: t (195) = -4.77, p<0.01, technical: t (195) = -4.69, p<0.01). Facilities located in urban areas scored higher on two of the four quality of care elements as compared with rural facilities (infrastructure: t (195) = -3.92, p<0.01, technical: t (195) = -3.42, p<0.01).

As with antenatal care, each item of the different quality of care element scores was separately assessed to identify the drivers.

Table 4.5: Facility level mean and standard deviation of labor and delivery quality measures across the 197 labor and delivery facilities

	Infrastructure	**Human resources**	**Technical**	**Interpersonal**
Number of items	25	13	18	11
Range	0-1			
Overall	0.69 (0.13)	0.44 (0.15)	0.58 (0.12)	0.67 (0.15)
Operating authority				
Public	**0.68 (0.13)**	0.43 (0.15)	**0.57 (0.12)**	0.67 (0.15)
Private	**0.72 (0.13)**	0.46 (0.15)	**0.61 (0.12)**	0.68 (0.14)
Facility type				
Hospitals	**0.78 (0.10)**	**0.51 (0.14)**	**0.64 (0.11)**	0.67 (0.13)
Health centers	**0.65 (0.11)**	**0.41 (0.14)**	**0.55 (0.12)**	0.67 (0.16)
Urbanicity				
Urban	**0.76 (0.11)**	0.47 (0.15)	**0.64 (0.10)**	0.69 (0.13)
Rural	**0.67 (0.13)**	0.44 (0.15)	**0.57 (0.12)**	0.67 (0.15)

Bold indicates significant difference on t-test of means

For Aim 1, all labor and delivery quality elements were aggregated to the facility level. Each facility had an average of 2 labor and delivery observations, with a minimum of 1 and a maximum of 11. Table 4.6 shows the technical and interpersonal process measures across all labor and delivery patients nested within the facilities. For technical quality, hospitals and facilities located in urban areas had significantly higher quality than health centers (t (386) = -5.65, p<0.01) and facilities in rural areas (t (386) = -4.45, p<0.01). There was a significant difference in interpersonal process quality between primiparous and multiparous women, with primiparous women receiving better interpersonal process quality (t (381) = -2.26, p= 0.02).

Table 4.6: Patient level distribution of labor and delivery process quality measures among the 388 labor and delivery observations

	Technical	**Interpersonal**
Range	0-1	
	mean (sd)	
Overall	0.59 (0.13)	0.67 (0.16)
Parity (N=383)		
Primipara	0.61 (0.12)	**0.70 (0.14)**
Multipara	0.59 (0.14)	**0.66 (0.16)**
Operating authority		
Public	0.59 (0.13)	0.67 (0.16)
Private	0.60 (0.14)	0.66 (0.16)
Facility type		
Hospitals	**0.63 (0.13)**	0.66 (0.16)
Health centers	**0.56 (0.12)**	0.67 (0.16)
Urbanicity		
Urban	**0.63 (0.12)**	0.67 (0.16)
Rural	**0.57 (0.13)**	0.67 (0.16)

Bold indicates significant difference on t-test of means

4.2.2.4 *Floor/ceiling effects*

Each quality of care index was assessed for floor and ceiling effects by calculating the percentage frequency of the lowest (floor) or highest (ceiling) possible score. The lowest possible score on all indices was zero, while the highest possible score was one. Floor or ceiling effects

are defined as 15% (or more) at the lowest or highest score [1, 2]. Table 4.7 shows that no floor or ceiling effects were observed in the labor and delivery quality of care measures.

Table 4.7: Floor and ceiling effects in the facility level labor and delivery quality measures among 197 facilities

	Infrastructure	Human Resources	Technical	Interpersonal
Floor	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Ceiling	1 (0.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)

Floor = Score of 0, Ceiling = Score of 1

4.2.2.5 *Observer effects*

As discussed in section 1.5.2.2, direct observations are considered the 'gold standard' to measure process quality [3]. However, observation introduces the potential for subjectivity, which can introduce bias in ratings.

In multi-stage cluster samples such as the one used for this study, all observations for a given primary sampling unit, in this case the facility, are frequently assigned to one interviewer. In this sample, over 83% of facilities had only one observer doing all observations, as shown in Table 4.8.

Table 4.8: Distribution of observers over 400 antenatal facilities

Number of observers	Number of facilities (Percent)
1	333 (83.3%)
2	58 (14.5%)
3	8 (2%)
4	1 (0.3%)

Controlling for this potential bias presents a challenge discussed by O'Muicheartaigh and Campanelli in which the variance due to individual interviewer and the variance due to the facility are confounded [4]. The only way to remove such confounding is at the design stage, by using an interpenetrated design where respondents are assigned at random to interviewers. The

2013 Malawi SPA did not use an interpenetrated design, therefore the measures which were based on clinical observations were assessed for observer bias in the analysis stage.

Two mixed effects linear models were assessed, one for the technical process score and the other for the interpersonal process score, with fixed effects for observer and a random intercept for facility. The following facility level and patient level fixed effects were also included: facility type, operating authority, years of education, parity, distance from facility, and whether it was the patient's first antenatal care visit. This analysis showed that observers did not have a significant effect on either the technical process ($p = 0.19$) or interpersonal process score ($p = 0.11$). Estimates from the models with the fixed effect for observer were then compared with the same model removing the fixed effect for observer – the nested model – using a likelihood ratio test. In both cases, the likelihood ratio test was non-significant (technical process $p = 0.10$; interpersonal process $p = 0.18$), indicating that there is no added benefit to including the observer fixed effect.

4.2.3 **Assumptions check for Pearson's correlations**

Pearson's correlation is based on certain assumptions regarding distribution: normal distribution for each variable, absence of outliers, and a linear relationship between the variables. These assumptions were tested as follows:

- ***Normality:*** Each measure was assessed for normality using the Shapiro-Wilk test with significance set at $p<.05$. All of the indices for antenatal care were normally distributed. All of the indices for labor and delivery care were normally distributed except for interpersonal care ($p<0.001$). No transformation of that index yielded a normal distribution and so scores were analyzed as originally calculated, without transformation.

- ***Outliers:*** Box plots of the univariate distributions of each measure were visually assessed for outliers. Outliers were defined as any value less than 1.5 times the interquartile range below the 25th percentile and greater than 1.5 times the interquartile range above the 75th percentile. As shown in Table 4.9, over half of the measures had at least one outlier.

Table 4.9: Number and proportion of outlier values for each quality of care measure

	Antenatal facilities (n=400)		**Labor and delivery facilities (n=197)**	
	n	**%**	**n**	**%**
Infrastructure	1	0.3%	5	2.5%
Human Resources	17	4.3%	0	0.0%
Technical Process	1	0.3%	0	0.0%
Interpersonal	0	0.0%	1	0.5%

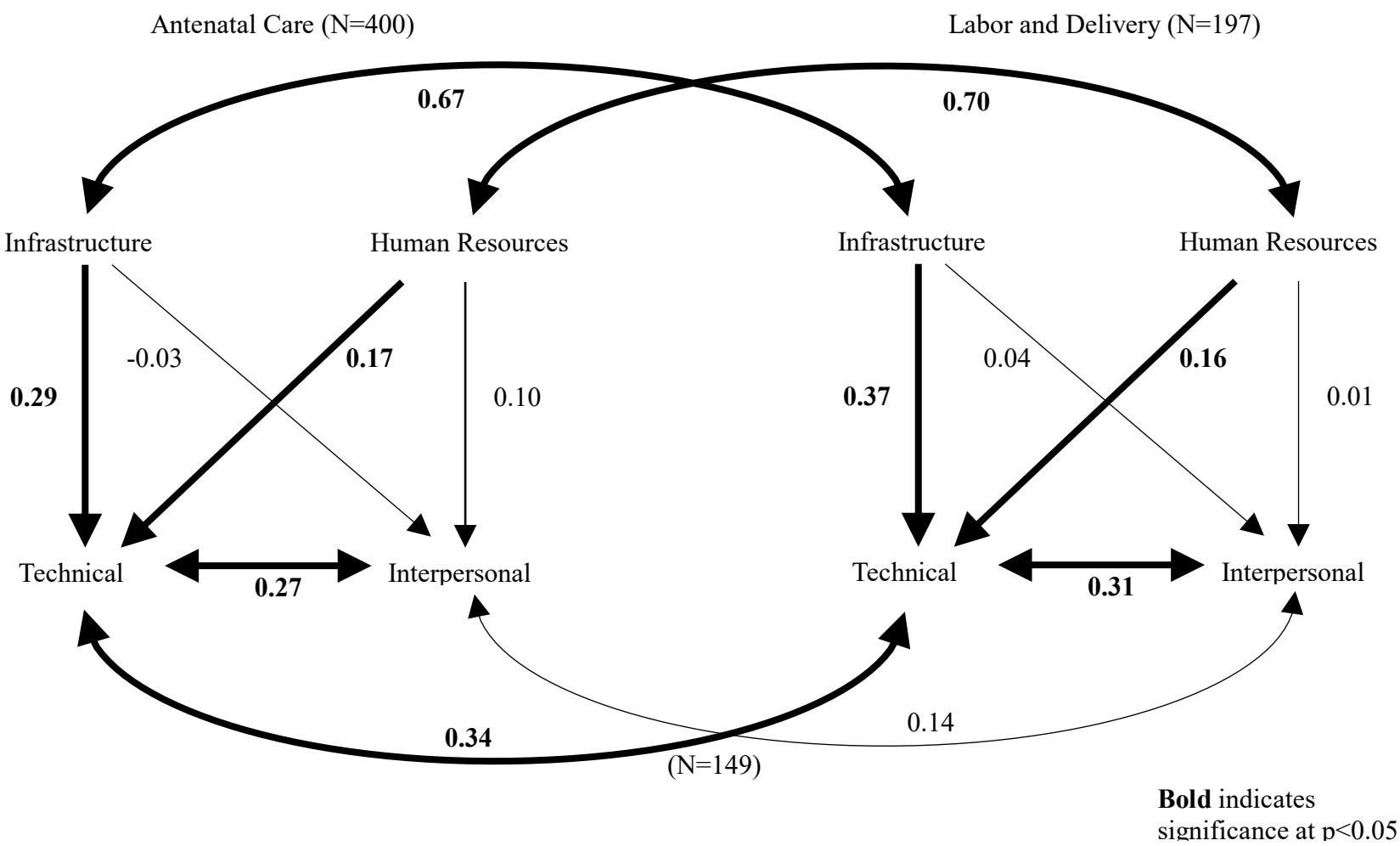
- ***Linear association:*** Scatter plots of the joint distribution of each pair of variables suggested that associations were linear.

Due to the presence of at least one outlier in over half of the measures, Spearman's correlations were calculated and reported here.

4.2.4 **Main findings**

Figure 4.1 shows results from the Aim 1 correlation analyses. Associations of structural elements – infrastructure and human resources – with process quality elements – technical and interpersonal – are presented first, followed by associations of quality elements within the same facility.

Figure 4.1: Aim 1 correlations among antenatal and labor and delivery structure and process quality elements



4.2.4.1 *Hypothesis 1.1: Infrastructure is positively correlated with (a) technical and (b) interpersonal quality in both antenatal and labor and delivery care.*

Infrastructure and technical process quality were significantly positively correlated in both antenatal care ($r = 0.29$, $p<0.001$) and labor and delivery care ($r= 0.37$, $p<0.001$). Infrastructure and interpersonal process quality were not significantly correlated in either antenatal care ($r = -0.03$, $p = 0.56$) or labor and delivery care ($r = 0.04$, $p = 0.60$).

4.2.4.2 *Hypothesis 1.2: Human resources are positively correlated with (a) technical and (b) interpersonal quality in both antenatal and labor and delivery care.*

Human resources and technical process quality were significantly positively correlated in both antenatal care ($r = 0.17$, $p<0.001$) and labor and delivery care ($r = 0.16$, $p = 0.02$). Human resources and interpersonal process quality were also significantly positively correlated in antenatal care ($r = 0.10$, $p = 0.01$), but not in labor and delivery care ($r= 0.01$, $p = 0.63$).

4.2.4.3 *Hypothesis 1.3: Labor and delivery technical quality is positively correlated with antenatal technical quality.*

At facilities providing both antenatal and labor and delivery services, the technical process quality between the two was significantly positively correlated ($r = 0.34$, $p<0.001$).

4.2.4.4 *Hypothesis 1.4: Labor and delivery interpersonal quality is positively correlated with antenatal interpersonal quality.*

At facilities providing both antenatal and labor and delivery services, the interpersonal process quality between the two was not significantly correlated ($r = 0.14$, $p = 0.03$).

4.2.5 **Sensitivity analyses**

4.2.5.1 *Accounting for observer bias*

Potential bias introduced by the Hawthorne effect was assessed for the technical and interpersonal process quality scores. Scores on the first observation for a given provider were compared against subsequent observations for each score using t-tests. Results showed no significant difference between technical process quality at the first observation for a given

provider (mean = 0.54, SD = 0.17) and technical process quality at subsequent observations (mean = 0.54, SD = 0.16) (t (2008) = -0.34, p = 0.73). Similarly, there was no significant difference between interpersonal process quality at the first observation for a given provider (mean = 0.55, SD = 0.19) and technical process quality at subsequent observations (mean = 0.55, SD = 0.19) (t (2008) = 0.05, p = 0.96).

4.2.5.2 *Group comparisons*

The associations between the quality ratings were examined within different types of facilities. First, public and privately managed facilities were compared. No significant differences between the groups emerged. However, one association that was not statistically significant in the overall analysis became significant when examined in privately managed facilities only (See Table 4.10.). In private facilities, better antenatal human resource quality was associated with better antenatal interpersonal process quality (r = 0.21, p = 0.01), however this was only a weak correlation.

Next, hospitals and health centers were examined separately. One association, between antenatal human resources and antenatal interpersonal quality, became significant when examined in only health centers (r = 0.12, p = 0.03) (See Table 4.10.). Tests of equality showed that only one of the differences in correlation coefficient between hospitals and health centers were statistically significant at p<0.05. The correlation between labor and delivery human resources and labor and delivery technical process quality was statistically different, with a null correlation at health centers and a correlation of 0.29 at hospitals.

Table 4.10: Comparison of correlations among quality elements in different types of facilities (private vs public, health centers vs hospitals)

		Overall	Private facilities	Public facilities	Health Centers	Hospitals
		n=400	n=134	n=266	n=314	n=86
Antenatal Care	Infrastructure with Technical process	0.29*	0.16	0.28*	0.26*	0.03
	Infrastructure with Interpersonal process	-0.03	0.00	-0.05	-0.06	0.13
	Human Resources with Technical process	0.17*	0.14	0.17*	0.14*	-0.03
	Human Resources with Interpersonal process	0.10	0.21*	0.04	0.12*	0.04
		n=197	n=62	n=135	n=133	n=64
Labor and Delivery Care	Infrastructure with Technical process	0.37*	0.41*	0.36*	0.25*	0.25*
	Infrastructure with Interpersonal process	0.04	0.05	0.04	0.02	0.16
	Human Resources with Technical process	0.16*	0.34*	0.08	**-0.02**	**0.29***
	Human Resources with Interpersonal process	0.01	0.11	-0.03	0.03	-0.04
Antenatal Technical Process with Labor and Delivery Technical Process		0.34*	0.32* n=48	0.30* n=101	0.21* n=90	0.30* n=59
Antenatal Interpersonal Process with Labor and Delivery Interpersonal Process		0.14	0.28 n=48	0.07 n=101	0.18 n=90	0.06 n=59

*Correlation coefficient significant at $p<0.05$

Bold indicates significantly different correlation coefficient between the two groups (private *vs*. public, health center *vs*. hospital)

4.3 AIM 2

Aim 2 was to evaluate the association of facility structure and process quality of antenatal care with patient satisfaction with antenatal care.

4.3.1 Sample

The sample for Aim 2 was limited to women attending antenatal care at facilities providing antenatal care services which had complete data, who completed the patient satisfaction questions in the exit interview. At the facility level, this sample was the same as the sample of facilities providing antenatal care services used in Aim 1. Table 4.2 summarized characteristics of the 400 facilities.

Overall, 2043 women attended antenatal care at those facilities and were included in the sample. Table 4.11 summarizes their characteristics. The women were primarily between the ages of 21-30 (49%), had not attended secondary school (76.5%), were pregnant for the second or greater time (75.6%), and were on their second or later antenatal care visit of their pregnancy (59.0%). Nearly three-quarters of the women saw female providers (71.5%).

Table 4.11: Descriptive characteristics of 2043 patients in the Aim 2 sample

	N	(%)
Age		
<=20	567	27.8
21-30	1002	49.0
>30	474	23.2
Did not attend secondary school*	1538	76.5
First pregnancy **	499	24.4
Closest facility to home ***	1831	89.6
First antenatal visit	837	41.0
Saw a female provider	1461	71.5

*N=2010 for education
**N=2034 for first pregnancy
***N=2009 for closest facility to home

Table 4.12 shows differences in patient characteristics by facility characteristics in the Aim 2 sample. Women with lower levels of education were more likely to attend antenatal care at health centers as compared to women with more education (χ^2 (2, N = 2010) = 68.65, p<0.001), and women who were attending antenatal care at the closest facility to their home were more likely to be at a health center when compared with women who were attending antenatal care at a facility that was not the closest on to their home (χ^2 (2, N = 2009) = 60.30, p<0.001). The same pattern was observed for public vs private facilities, with women with lower levels of education more likely to attend antenatal care at public facilities as compared to women with more education (χ^2 (2, N = 2010) = 4.75, p<0.05), and women who were attending antenatal care at the closest facility to their home were more likely to be at a public facility when compared with women who were attending antenatal care at a facility that was not the closest on to their home (χ^2 (2, N = 2009) = 9.08, p<0.05).

Table 4.12: Bivariate associations of patient and facility characteristics in the Aim 2 sample of 2043 patients

	Health Centers N=1527	**Hospitals N=516**	**p-value**		**Private N=581**	**Public N=1462**	**p-value**
Did not attend secondary school*	**81.1%**	**63.1%**	**<0.001**		**73.3%**	**77.8%**	**<0.05**
Primipara**	25.0%	23.1%	0.38		23.6%	24.9%	0.53
At closest facility to home***	**94.0%**	**82.7%**	**<0.001**		**88.1%**	**92.4%**	**<0.01**
First antenatal visit	59.3%	58.1%	0.63		61.6%	58.0%	0.27

Bold indicates significance at p<0.05 using chi-squared test
*N=2010
**N=2034
***N=2009

4.3.2 **Quality of care**

Aim 2 utilizes multilevel modeling to assess associations of the antenatal quality of care measures with patient satisfaction. Two of the four quality of care measures – technical care and interpersonal care – were measured at the patient level and so could be characterized both at that level and by aggregate measures at the facility level. Table 4.3 showed facility level measures of

antenatal technical and interpersonal quality. Table 4.13 shows the univariate and bivariate distributions of technical and interpersonal quality at patient level. Overall technical process quality was 0.49 (SD: 0.18), while interpersonal process quality was 0.55 (SD: 0.19). The means at the patient level are the same as the facility level, however the standard deviations are slightly larger at the patient level.

Table 4.13: Patient-level mean and standard deviation of antenatal quality measures for 2043 patients

	Technical	**Interpersonal**
Number of items in the measure	9	7
Range	0-1	
Overall	0.49 (0.18)	0.55 (0.19)
First antenatal visit		
Yes	**0.48 (0.18)**	0.55 (0.19)
No	**0.51 (0.18)**	0.55 (0.19)
Education*		
Did not attend secondary school	**0.48 (0.18)**	0.55 (0.19)
Attended secondary school or higher	**0.53 (0.19)**	0.57 (0.18)
Parity **		
Primipara	0.48 (0.19)	0.55 (0.19)
Multipara	0.50 (0.18)	0.55 (0.18)
Distance ***		
Not nearest facility	**0.53 (0.19)**	**0.58 (0.19)**
Nearest facility	**0.49 (0.18)**	**0.55 (0.19)**

Bold indicates significant difference on t-test of means
*N=2010 for education
**N=2034 for parity
***N=2009 for distance

Technical process quality varied significantly by several patient characteristics. Women attending their first antenatal care visit received worse technical care compared with women who were not at their first antenatal visit (t (2041) = 4.03, p<0.001). More educated women received better technical care compared with less educated women (t (2041) = -4.67, p<0.001), and women who travelled farther to get antenatal care had better technical care compared with women who were at the nearest facility to their home (t (2041) = 2.78, p<0.01).

Interpersonal process quality varied significantly the distance a woman travelled to get antenatal care. Similar to technical care, women who travelled farther to get antenatal care had better interpersonal care compared with women who were at the nearest facility to their home (t (2041) = 2.48, p = 0.01).

4.3.2.1 *Floor and ceiling effects*

Table 4.14 shows that no floor or ceiling effects were noted at the patient level.

Table 4.14: Patient level floor and ceiling effects among 2043 patient-provider observations of technical and interpersonal process quality

	Technical Process Quality	**Interpersonal Process Quality**
Ceiling	2 (0.1%)	29 (1.4%)
Floor	11 (0.5%)	3 (0.1%)

4.3.2.2 *Intra-class correlation*

As described in Chapter 3, the intra-class correlation (ICC) is the proportion of the variance explained by the grouping structure in multilevel data. Technical process quality had an ICC of 0.75 (95% CI: 0.71, 0.78), indicating that 75% of the variation in this measure is across facilities. Interpersonal process quality had an ICC of 0.67 (95% CI: 0.63, 0.70).

4.3.3 **Patient Satisfaction**

Patient satisfaction was assessed using an 11-item index as described in Chapter 3. Scores could range from 0 to 1. Table 4.15 shows the bivariate distributions of patient satisfaction. Overall mean patient satisfaction was 0.90 (SD 0.14). Patient satisfaction varied significantly for women with differing years of schooling. Women attending private facilities and hospitals had significantly higher patient satisfaction than those attending public facilities and health centers, respectively.

Table 4.15: Patient satisfaction score by key patient and facility characteristics, mean (SD), N=2043

	Mean patient satisfaction (SD)
Patient characteristics	
First antenatal visit	
Yes	0.90 (0.14)
No	0.91 (0.14)
Education (N=2010)	
Did not attend secondary school	**0.91 (0.14)**
Attended secondary school	**0.89 (0.14)**
Parity	
Primipara	0.90 (0.13)
Multipara	0.91 (0.14)
Distance (N=2009)	
Facility closest to home	0.91 (0.14)
Not facility closest to home	0.90 (0.14)
Facility characteristics	
Operating authority	
Private	**0.92 (0.12)**
Public	**0.90 (0.15)**
Facility type	
Health center	**0.90 (0.15)**
Hospital	**0.93 (0.11)**
Urbanicity	
Rural	0.90 (0.14)
Urban	0.91 (0.13)

Bold indicates significant difference on t-test of means

4.3.3.1 *Intraclass correlation*

As discussed in Chapter 3, the intraclass correlation of the outcome variable and the design effect due to clustering are both important to assess before conducting a multilevel analysis. In this case, patient satisfaction had an ICC of 0.24 (95% CI: 0.19, 0.28). An outcome with an ICC of over 0.1 indicates the need for a multilevel analysis approach, therefore the multilevel approach was maintained. The design effect was calculated as 2. Muthen recommends multilevel approaches when the design effect is 2 or above [5].

4.3.4 **Model modifications**

In the model initially proposed in Chapter 3, certain variables were considered as covariates based on past research on patient satisfaction (See Table 3.11.). One step of the exploratory data analysis was to assess the correlation of each of these candidate covariates with the others. Any covariate correlated with any other covariate at greater than 0.3, a medium sized correlation, would be considered for removal due to the risk of multicollinearity. Of the three candidate facility level covariates, urbanicity was removed because its correlation with type of health facility exceeded the prescribed cut point ($\rho = 0.4$). Urbanicity was removed instead of type of health facility due to the stronger evidence of a link between type of health facility and patient satisfaction [6, 7].

None of the patient level candidate covariates were correlated above the cut point.

4.3.5 **Hypothesis 2.1: All four quality of care indices - infrastructure, human resources, technical, and interpersonal - are positively and directly associated with facility level patient satisfaction with antenatal care received, after controlling for other covariates.**

Of the 2043 women meeting the sample inclusion criteria, 43 had missing data on independent variables. Therefore, the analytic sample included the 2000 women with complete data. The associations of the quality of care elements and covariates with patient satisfaction were tested in increasingly complex models. Associations of facility level quality of care elements are discussed first, followed by other facility level covariates and patient level quality of care elements and covariates.

4.3.5.1 *Description of models tested*

In the first model, associations of each quality of care element and covariate individually with patient satisfaction were tested using simple linear regression models. In this simplest of models, each covariate was tested separately with patient satisfaction.

In the second model, the associations of each quality of care element and covariate individually with patient satisfaction were tested using bivariate linear mixed model which takes into account the clustering of patients within facilities.

The third model tested associations of quality elements with patient satisfaction derived using a single multilevel path model which incorporated all four quality of care elements but no covariates. At the facility level, this approach tested both the direct paths from each of the four quality elements to patient satisfaction and also the indirect paths from infrastructure and human resources to patient satisfaction through technical and interpersonal process quality. At the patient level, this approach tested the direct paths from technical and interpersonal process quality to patient satisfaction.

The fourth and final model tested associations of quality elements with patient satisfaction derived from a single multilevel path model which incorporated all four quality of care elements and all patient and facility level covariates.

Standardized regression coefficients, also called path coefficients [8], are reported for each of the models. Unstandardized path coefficients are included in Appendix C. Standardized coefficients are calculated by transforming all variables to have a mean of zero and a standard deviation of one. A stardardized coefficient for a continuous independent variable indicates how much change there is in the dependent variable, on average, for a one standard deviation change in the independent variable, expressed in terms of the standard deviation of the dependent variable. In this way the standardized coefficients allow for a determination of the relative importance (weight) of each independent variable. In the case of binary independent variables, the standardized coefficient indicates how much change there is in the dependent variable, on average, when x changes from zero to one, expressed in terms of the standard deviation of the dependent variable [9].

4.3.5.2 *Facility level quality of care associations with patient satisfaction*

Table 4.16 shows results of the models described in the previous section.

Column 1 shows that in separate simple linear regression models, the infrastructure (β=0.05, p<0.05) and interpersonal process (β=0.04, p<0.05) elements of quality of care were both significantly positively associated with patient satisfaction.

Column 2 shows that in separate linear mixed regressions which account for clustering at the facility level, the associations of quality infrastructure and interpersonal quality with patient satisfaction are attenuated, with no significant associations identified.

Column 3 shows results of the third model. In this model, at the facility level, only interpersonal process quality was associated with patient satisfaction (β=0.12, p = 0.08). The overall R^2 for the facility level model was 0.02, meaning that 2% of the variance in facility level mean patient satisfaction could be predicted from the facility level mean quality of care elements.

Column 4 shows the results of the fourth model, the full multilevel path model. In this model, interpersonal process quality had a stronger and more significant association with patient satisfaction (β=0.14, p = 0.03). Figure 4.2 shows the facility level path model with the standardized path coefficients for Model 4. The overall R^2 for the facility level model was 0.10, so in this case 10% of the variance in facility level mean patient satisfaction could be predicted from the facility level mean quality of care elements and the facility level covariates.

Table 4.16: Associations of quality of care elements and covariates with patient satisfaction in increasingly complex models, N=2000 patients, n=400 facilities, standardized β (SE)

	1	2	3	4
	Simple linear regression models	Linear mixed models	Simple ML path model	Full ML path model
Facility level				
Infrastructure	0.05 (0.02) **	0.08 (0.06)	0.10 (0.07)	0.03 (0.07)
Human Resources	-0.02 (0.02)	-0.04 (0.06)	-0.06 (0.07)	-0.09 (0.07)
Technical	0.01 (0.02)	0.02 (0.06)	-0.04 (0.07)	-0.09 (0.07)
Interpersonal	0.04 (0.02) **	0.10 (0.06)	0.12 (0.07) *	0.14 (0.07) **
Hospital (ref: Health center)	0.23 (0.05) **	0.45 (0.12) **	NA	0.54 (0.14) **
Public (ref: Private)	-0.16 (0.05) **	-0.35 (0.12) **	NA	-0.31 (0.12) **
			R^2=0.02	R^2=0.10
Patient level				
Technical	0.01 (0.02)	0.00 (0.03)	-0.01 (0.03)	-0.00 (0.03)
Interpersonal	0.04 (0.02) **	0.04 (0.03)	0.01 (0.03)	0.02 (0.03)
First antenatal visit (ref: Not first antenatal visit)	0.01 (0.05)	0.02 (0.05)	NA	0.04 (0.06)
Attended secondary school (ref: Did not attend secondary school)	-0.13 (0.05) **	-0.15 (0.06) **	NA	-0.19 (0.07) **
Multipara (ref: Primipara)	0.01 (0.05)	-0.01 (0.05)	NA	0.03 (0.05)
Closest facility to home (ref: Not nearest facility to home)	-0.05 (0.08)	-0.04 (0.09)	NA	0.01 (0.09)
			R^2=0.00	R^2=0.01

*p<0.10; **p<0.05

Column 1 presents simple linear regressions of patient satisfaction on each covariate separately. Associations are expressed as standardized linear regression coefficients, β, with standard error.

Column 2 presents a linear mixed model to account for clustering at facility level. Associations are expressed as standardized linear regression coefficients, β, with standard error.

Column 3 includes direct effects of all quality elements on patient satisfaction and indirect effects of infrastructure and human resources on patient satisfaction through technical and interpersonal process. Associations are expressed as standardized linear regression coefficients, β, with standard error.

Column 4 includes all quality elements as in Column 3 and adds covariates[26]. Associations are expressed as standardized linear regression coefficients, β, with standard error.

[26] Facility level covariates are level (hospital vs health center) and operating authority (public vs private). Patient level covariates are number of antenatal care visits (First ANC vs later ANC), education (attended secondary school vs not), parity (first pregnancy vs later pregnancy), and distance (attending ANC at the closest facility to home vs not).

4.3.5.3 *Other facility level covariates*

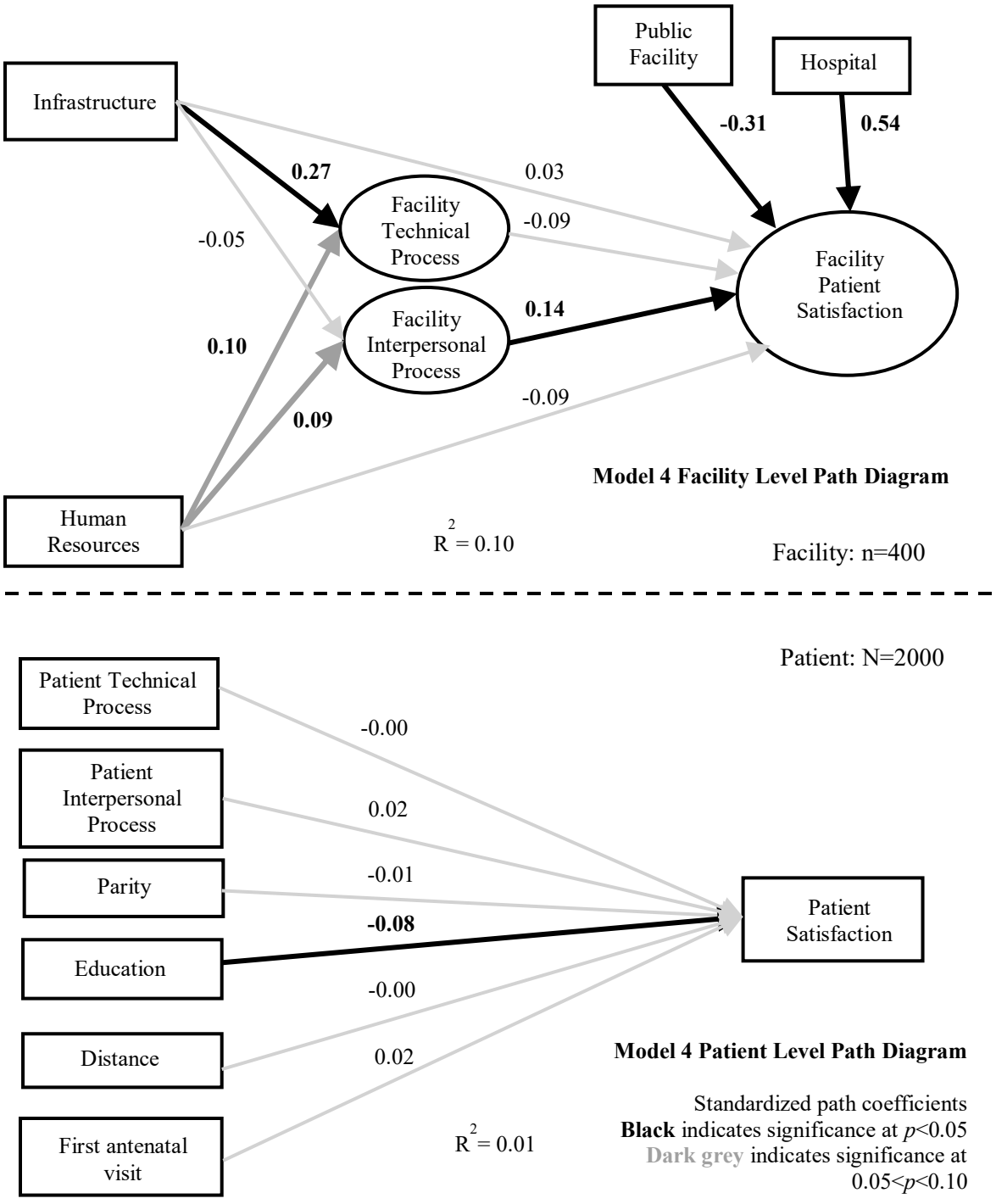
Other non-quality of care covariates included in the models had significant associations with patient satisfaction. Both facility level characteristics, facility type and operating authority, had statistically significant associations in each model. Column 4 of Table 4.16 showed that, on average, women at hospitals had significantly higher patient satisfaction when compared with women at health centers ($\beta = 0.54$, $p<0.001$). Column 4 also showed that, on average, women at public facilities had significantly lower patient satisfaction when compared with women at private facilities ($\beta = -0.31$, $p<0.05$).

4.3.5.4 *Patient level covariates*

At the patient level, a woman's education level maintained a statistically significant association throughout the models. Women with higher levels of education consistently had lower patient satisfaction scores when compared with women with lower levels of education (Column 4: ($\beta = -0.19$, $p<0.01$)). Figure 4.2 shows the patient level path model with standardized path coefficients for the full multilevel path model tested in Column 4.

Patient level covariates accounted for a negligible proportion of the variance in patient satisfaction.

Figure 4.2: Model 4 Multilevel path analysis with standardized coefficients. Facility and patient level models were fit simultaneously.



4.3.6 **Hypothesis 2.2: The two process quality indices – technical and interpersonal – mediate the association of the two structural quality indices – infrastructure and human resources- with women's satisfaction with antenatal care received.**

Both of the structural quality measures – infrastructure and human resources – were hypothesized to have indirect effects on patient satisfaction, through the two process quality measures – technical and interpersonal. As discussed in section 3.8.2, the significance test for indirect effect in Mplus makes incorrect assumptions about the distribution of the indirect effects[27]. Significance was therefore assessed using the Monte Carlo method for assessing mediation, which makes no assumptions about the distribution of the indirect effect and calculates asymmetric confidence intervals which are more appropriate. If the Monte Carlo 95% confidence interval includes 0, then the effect is not statistically significant.

Using the Monte Carlo 95% confidence interval method, neither structural quality element – infrastructure nor human resources – had a significant indirect effect on patient satisfaction through either technical process or interpersonal process quality (See Table 4.17 and Table 4.18). Coefficients included in Tables 4.17 and 4.18 differ slightly from those in Figure 4.2 and Table 4.16 as they are the unstandardized rather than the standardized path coefficients (β).

[27] The Sobel test, which is commonly used to test indirect effects, and which is calculated in Mplus, uses a z-test to test for significance of the indirect effect. However, z-tests assume that the indirect effects are normally distributed over repeated sampling, which is not true. Using the Monte Carlo method makes no assumptions about the distribution of the indirect effect and therefore yields confidence intervals which are faithful to the skewed sampling distributions of indirect effects.

Table 4.17: Facility level total, direct, and indirect effects of infrastructure on patient satisfaction, N=2000 patients, n=400 facilities

Infrastructure	Unstandardized β	Standard Error	Monte Carlo 95% CI
Total effect	0.00		
Direct effect	0.01	0.03	
Indirect effect (through technical process)	-0.01	0.01	(-0.03, 0.01)
Indirect effect (through interpersonal process)	-0.00	0.00	(-0.01, 0.00)

Standard Errors were calculated in Mplus using the Sobel test.

Monte Carlo 95% confidence intervals for indirect effects were calculated using the Monte Carlo method for assessing mediation method as described in Chapter 3 [10].

Table 4.18: Facility level total, direct, and indirect effects of human resources on patient satisfaction, N=2000 patients, n=400 facilities

Human Resources	Unstandardized β	Standard Error	Monte Carlo 95% CI
Total effect	-0.05		
Direct effect	-0.05	0.03	
Indirect effect (through technical process)	-0.01	0.01	(0.00, 0.00)
Indirect effect (through interpersonal process)	0.01	0.01	(-0.00,0.02)

Standard Errors were calculated in Mplus using the Sobel test.

Monte Carlo 95% confidence intervals for indirect effects were calculated using the Monte Carlo method for assessing mediation method as described in Chapter 3 [10].

4.3.7 **Fit statistics**

Goodness-of-fit measures do not work equally well with different sample sizes, estimators, and distributions. Therefore, assessing multiple goodness-of-fit measures is recommended [11]. In this case, four measures of goodness-of-fit were used to determine how well the proposed model fit the data: chi-square, root mean square error of approximation (RMSEA), standardized root mean square residual (SRMR), and the comparative fit index (CFI). Table 4.19 summarizes results.

Table 4.19: Goodness-of-fit measures for patient satisfaction model

	Result	Acceptable fit[28]	Poor fit
Level-specific			
SRMR-between	0.05	+	
SRMR-within	0.08	+	
Overall model			
Chi-square	93.18, df=13, p<0.01		+
RMSEA	0.06	+	
CFI	0.51		+

As discussed in Chapter Three, most goodness of fit statistics were developed only for single level structural equation models, and have not been tested in multilevel contexts. However, there is limited evidence on appropriate goodness of fit measures in multilevel contexts, and researchers still commonly use the single level goodness of fit measures for multilevel path analysis and SEM [12-14].

The SRMR is the only fit index that has been modified in Mplus to assess each level of a multilevel model. The SRMR is derived from the deviation between the observed variance–covariance matrix and the model-implied variance–covariance matrix [15]. Both the single level and the level-specific SRMR have been shown to do well in identifying model misspecification [11, 16]. SRMR values at or below 0.08 indicate acceptable model fit [11]. This model had an SRMR-within of 0.08 and an SRMR-between of 0.05.

The chi-square test evaluates whether there is a statistically significant difference between the covariance matrix implied by the hypothesized model and the covariance matrix of the observed variables in the population. Good fit would be indicated by a non-significant chi-square test [17]. While chi-square is the most frequently reported fit index to assess overall model fit, it is sensitive to three factors: sample size, model size, and non-normality of any of the variables [18]. Larger samples tend to produce significant chi-square statistics, indicating poor fit.

[28] Goodness of fit statistic have different categories of fit. In this table, acceptable fit includes any goodness of fit statistics in the category of "very good", "good", or "adequate".

Chi-square also assumes multivariate normality; therefore, highly skewed and kurtotic variables can increase chi-square values. In this case, the chi-square test was significant ($p<0.01$), indicating poor model fit; however, this may be due to the large sample size, the large model, and the skewness of the outcome variable.

RMSEA is a fit index that assesses how close the implied model matrix is from the observed variance-covariance matrix. RMSEA takes into account the complexity of the model by adjusting for the number of parameters, and is among the fit indices least affected by sample size [19]. Values less than or equal to 0.06 indicate good fit [11]. This model had an RMSEA of 0.06.

CFI measures goodness of fit of the tested model when compared to a baseline model, which is typically an independence model in which the variances are estimated freely without any constraints and all the covariances are fixed to zero [20]. Anything above 0.95 indicates good fit [11]. The model here had a CFI of 0.51. This poor CFI may be due to the low correlations of the variables in the model with each other and the overall low proportion of variance in the outcome variable explained by the independent variables [21].

Taken together, these indices point to a barely adequately fitting model, the relevance and implications of which will be discussed in the next chapter.

4.3.8 **Sensitivity analyses**

Multiple sensitivity analyses were conducted to examine the extent to which the findings were affected by different analytical choices. However, these results should be interpreted with caution as this analysis was not powered for smaller sample sizes nor for multiple group comparison.

4.3.8.1 *Limiting the analysis to facilities with 2 or more observations*

Facilities with a single patient-provider observation were removed to better capture variation within versus between facilities. Out of the 400 facilities, there were 12 that had only

one observation. The results of hypothesis testing were similar when limiting the analysis to the 1988 patients at the 388 facilities with at least two patient-provider interactions.

4.3.8.2 *Accounting for observer bias*

In the 388 facilities with more than one observation, the first observation was removed in order to account for the Hawthorne effect. This reduced the sample by 20.0% to 1600 patients at the 388 facilities. As discussed in section 1.2.5.1, there were no significant differences in technical or interpersonal process quality when the first observations were removed, therefore this planned sensitivity analysis was not conducted.

4.3.8.3 *Group differences*

The multilevel path analysis was repeated for subsets of facilities to identify differences in coefficients for certain groups. These analyses were not adjusted for multiple comparisons. Table 4.20 shows the results of this group analysis.

Table 4.20: Facility and patient level associations of covariates with patient satisfaction in subsets of facilities (Public vs private, hospitals vs health centers), N=2000 patients, n=400 facilities, standardized β coefficients with standard error

	Public	Private	Hospitals	Health Centers
Facility				
Quality elements				
Infrastructure	**0.13 (0.08)**	**-0.25 (0.10) ****	-0.17 (0.11)	0.09 (0.08)
Human Resources	-0.14 (0.08) *	-0.01 (0.13)	0.13 (0.14)	-0.13 (0.07) *
Technical	-0.13 (0.09)	0.02 (0.12)	0.08 (0.19)	-0.13 (0.08)
Interpersonal	0.12 (0.08)	0.27 (0.14) *	-0.02 (0.16)	0.18 (0.08) **
Covariates				
Hospital	0.51 (0.19) **	0.64 (0.22) **	NA	NA
Public	NA	NA	-0.41 (0.27)	-0.29 (0.15) *
Patient-level				
Quality elements				
Technical	0.01 (0.03)	-0.05 (0.04)	**-0.11 (0.04) ****	**0.04 (0.03)**
Interpersonal	0.04 (0.04)	-0.06 (0.06)	0.05 (0.07)	0.01 (0.03)
Covariates				
Education	**-0.25 (0.08) ****	**-0.02 (0.11)**	-0.25 (0.10) **	-0.17 (0.08)
First antenatal care visit	0.03 (0.06)	0.03 (0.10)	0.04 (0.10)	0.04 (0.07)
Parity	-0.06 (0.06)	0.08 (0.09)	0.04 (0.10)	-0.05 (0.06)
Distance	0.04 (0.11)	-0.09 (0.13)	0.05 (0.14)	-0.05 (0.12)

Asterisks indicate a significant association of the covariate with patient satisfaction within the group (public, private, hospital, or health center): *p<0.10; **p<0.05

Bold indicates a significant difference in association (p<0.05) by facility operating authority (public vs private) or type (hospital vs health center).

The associations between quality elements and patient satisfaction were compared at public versus privately managed health facilities, with different patterns of associations emerging. Within public facilities, the only covariates which had a significant association with patient satisfaction were facility type and education. Within private facilities, only infrastructure and facility type had a significant association with patient satisfaction. However, when the two groups were compared, significant differences were only observed between the effects of infrastructure on patient satisfaction, which had a null association within public facilities and a significant negative association within private facilities, and education on patient satisfaction, which had a

significant negative association within public facilities, and a null association within private facilities.

When comparing the model on different facility types, namely hospitals and health centers, still different patterns of associations emerged. Within hospitals, only technical process and education were significantly associated with patient satisfaction, while within health centers, facility average interpersonal process was the only covariate significantly associated with patient satisfaction. When directly comparing the effects between hospitals and health centers, technical process was the only effect that was significantly different, with a significantly negative association with patient satisfaction at hospitals, and a null association within health centers.

4.3.8.4 *Cross-level interaction effects*

Patient education, facility operating authority, and facility type were strongly associated with patient satisfaction. Due to these strong associations, sensitivity analyses were carried out to evaluate whether the associations between facility type and operating authority and patient satisfaction differ by patient education. Cross-level interactions of patient education with facility operating authority, and of patient education with facility type were modeled and tested for significance. Neither cross-level interaction was statistically significant at $p<0.05$, indicating that association of patient education with patient satisfaction did not differ significantly by facility operating authority or type.

4.4 AIM 3

Aim 3 was to evaluate the association of facility structure and process quality of antenatal care with patients' intended delivery location among women who attended antenatal care at a facility with labor and delivery care services.

4.4.1 **Sample**

The sample for Aim 3 was limited to the subset of women who received antenatal care at facilities which also provided labor and delivery care. This included 1857 patients nested within 360 facilities. Despite being slightly smaller, the patient and facility level characteristics of the Aim 3 sample are similar to those of the Aim 2 sample.

Table 4.21 provides descriptive characteristics of the women in the Aim 3 sample. The largest proportion (48.9%) of women were between the ages of 21 and 30, with the remainder nearly evenly split between younger than 21 (27.8%) and over 30 (23.3%). Over three-quarters (76.3%) of women did not attend secondary school. For a quarter (24.6%) of women, this was their first pregnancy. Nearly all (89.5%) women were attending antenatal care at the facility closest to their home. Less than half of (41.5%) women were on their second or later antenatal care visit, and most (71.0%) saw a female provider for their antenatal care visit on the day of the observation.

Table 4.21: Descriptive characteristics of the 1857 women in the Aim 3 sample

Characteristic	**Patients**	
	N	(%)
Age		
<=20	517	27.8
21-30	908	48.9
>30	432	23.3
Did not attend secondary school	1394 (N=1827)	76.3
Primipara	456 (N=1848)	24.6
Closest facility to home	1661 (N=1826)	89.5
First antenatal visit	770	41.5
Saw a female provider	1318	71.0

Table 4.22 shows characteristics of the facilities in the Aim 3 sample. Among the three regions, there were far fewer facilities in the Northern Region (15.3%) when compared with Central and Southern Regions (42.5% and 42.2%). Over three-quarters (76.4%) were health

centers, and just over two-thirds (67.2%) were publicly operated. Most (83.3%) facilities were located in rural areas.

Table 4.22: Descriptive characteristics of the 360 facilities in the Aim 3 sample

Characteristic	**Facilities**	
Region	n	(%)
North	55	15.3
Central	153	42.5
South	152	42.2
Facility type		
Health Center	275	76.4
Hospital	85	23.6
Operating Authority		
Private	118	32.8
Public	242	67.2
Urbanicity		
Urban	60	16.7
Rural	330	83.3

Table 4.23 shows the differences in the patients within the different categories of facility in the Aim 3 sample. Women with lower levels of education were more likely to attend antenatal care at health centers as compared to women with more education (χ^2 (2, N = 1827) = 70.05, p<0.001), and women who were attending antenatal care at the closest facility to their home were more likely to be at a health center when compared with women who were attending antenatal care at a facility that was not the closest on to their home (χ^2 (2, N = 1826) = 69.78, p<0.001). When comparing public and private facilities, only women who were attending antenatal care at the closest facility to their home were more likely to be at a public facility when compared with women who were attending antenatal care at a facility that was not the closest on to their home (χ^2 (2, N = 1826) = 11.20, p<0.01).

Table 4.23: Bivariate associations of patient and facility characteristics in the Aim 3 sample of 1857 patients

	Hospitals N=513	**Health Centers N=1344**	**p-value**		**Private N=532**	**Public N=1325**	**p-value**
Did not attend secondary school	**62.9%**	**81.5%**	**<0.001**		73.9%	77.3%	0.13
Primipara	23.1%	25.3%	0.32		22.9%	25.4%	0.27
At closest facility to home	**82.6%**	**94.2%**	**<0.001**		**87.4%**	**92.4%**	**<0.01**
First antenatal visit	57.9%	41.2%	0.73		60.5%	57.7%	0.27

Bold indicates significant difference in association ($p<0.05$) by type (hospital vs health center) or facility operating authority (public vs private).
*N=1827
**N=1848
***N=1826

4.4.2 **Quality of care**

4.4.2.1 *Facility level quality of care*

Table 4.24 shows the mean facility level quality scores among the 360 facilities. Private facilities had better infrastructure (t (358) = 3.4, p<0.01), human resources (t (358) = 2.8, p<0.01), and technical process quality (t (358) = 4.1, p<0.01) when compared with public facilities. Hospitals had better infrastructure (t (358) = -7.7, p<0.01), human resources (t (358) = -5.3, p<0.01), and technical process quality (t (358) = -5.0, p<0.01) when compared with health centers. Urban facilities had better infrastructure (t (358) = -4.5, p<0.01), human resources (t (358) = -2.9, p<0.01), and technical process quality (t (358) = -3.4, p<0.01) when compared with facilities in more rural areas.

Table 4.24: Facility level mean and standard deviation of antenatal quality measures across the 360 antenatal facilities (Minimum possible quality score 0, Maximum possible quality score 1)

Antenatal quality of care at facilities	**Infrastructure**	**Human resources**	**Technical**	**Interpersonal**
Number of items in the measure	19	12	9	7
Overall	0.57 (0.16)	0.43 (0.14)	0.49 (0.16)	0.55 (0.16)
Operating authority				
Public	**0.55 (0.15)**	0.43 (0.14)	**0.47 (0.16)**	0.54 (0.17)
Private	**0.61 (0.17)**	0.45 (0.14)	**0.54 (0.17)**	0.55 (0.15)
Facility type				
Hospitals	**0.68 (0.16)**	**0.50 (0.14)**	**0.57 (0.17)**	0.55 (0.12)
Health center	**0.54 (0.15)**	**0.41 (0.13)**	**0.47 (0.16)**	0.55 (0.17)
Urbanicity				
Urban	**0.65 (0.17)**	**0.48 (0.13)**	**0.56 (0.18)**	0.54 (0.17)
Rural	**0.55 (0.15)**	**0.42 (0.14)**	**0.48 (0.16)**	0.56 (0.14)

Bold indicates a significant difference in association ($p<0.05$) by facility operating authority (public vs private) or type (hospital vs health center) or urbanicity (urban vs rural).

4.4.2.2 *Patient level quality of care*

Table 4.25 shows the mean scores for patient level technical and interpersonal process quality. Among the 1857 patients in the Aim 3 sample, women at their first antenatal care visit had better technical quality (t (1855) = 3.6, $p<0.01$) compared to women at later antenatal visits. Women with higher education had better technical quality (t (1825) = -3.9, $p<0.01$) and interpersonal quality (t (1825) = -2.1, $p<0.05$) compared with women with less education.

Table 4.25: Patient-level mean and standard deviation of antenatal quality measures in Aim 3 sample

	Technical	Interpersonal
	(N=1857)	
Overall	0.49 (0.18)	0.55 (0.19)
First antenatal visit	(N=1857)	
Yes	**0.51 (0.18)**	0.55 (0.19)
No	**0.48 (0.18)**	0.55 (0.19)
Education	(N=1827)	
Did not attend secondary school	**0.49 (0.18)**	**0.54 (0.19)**
Attended secondary school or higher	**0.53 (0.19)**	**0.57 (0.17)**
Parity	(N=1848)	
Primipara	0.48 (0.19)	0.55 (0.19)
Multipara	0.50 (0.18)	0.55 (0.18)
Distance	(N=1826)	
Not nearest facility	**0.54 (0.19)**	0.58 (0.19)
Nearest facility	**0.49 (0.18)**	0.55 (0.19)

Bold indicates a significant difference in association ($p<0.05$) by patient characteristic.

4.4.2.3 *Intraclass correlation*

Technical process quality had an intraclass correlation of 0.75 (95% CI: 0.71, 0.78). Interpersonal process quality had an intraclass correlation of 0.66 (95% CI: 0.62, 0.70).

4.4.3 **Intention to deliver at the same facility**

In the overall Aim 3 sample, 84.1% (1561/1857) of women intended to deliver at the same facility where they received antenatal care. Table 4.26 shows the bivariate statistics of intention to deliver with other key patient and facility level characteristics. Women with more years of education were less likely ($\chi2$ (2, N = 1827) = 7.00, $p<0.05$) to intend to deliver at the same facility (81.5%) as compared to women with fewer years of education (86.7%). The same was true of women who were pregnant for the first time, who were less likely ($\chi2$ (2, N = 1848) = 18.5, $p<0.01$) to deliver at the same facility (77.6%) as compared to women who had been pregnant before (86.1%). Women who attended antenatal care at hospitals were more likely ($\chi2$

(2, N = 1857) = 45.9, $p<0.01$) to intend to deliver at the same facility (93.4%) when compared to women attending antenatal care at health centers (80.5%).

Data were aggregated to the facility level to assess differences in the facility average proportion of women who intended to deliver at the same facility. The same differences were observed at the facility level as were identified in the overall patient sample: hospitals and facilities with less educated and more multiparous patients had higher proportions of women who intended to deliver at the same facility.

Table 4.26: Overall proportions of women intending to deliver at the same facility and associations of patient and facility characteristics with patient intention to deliver at the same facility among 1857 women attending antenatal care at 360 facilities

	Individual	Facility
	Proportion intending to deliver at the same facility	**Mean proportion who intend to deliver at the same facility (SD)**
Overall	84.1%	0.82 (0.24)
Patient characteristics		
First antenatal visit		
Yes	83.5%	0.84 (0.37)
No	84.5%	0.84 (0.36)
Education *		
Did not attend secondary school	**86.7%**	**0.89 (0.34)**
Attended secondary school	**81.5%**	**0.82 (0.39)**
Parity **		
Primipara	**77.6%**	**0.78 (0.42)**
Multipara	**86.1%**	**0.86 (0.35)**
Distance ***		
Nearest facility to home	85.4%	0.85 (0.35)
Not nearest facility to home	86.1%	0.86 (0.35)
Facility characteristics		
Operating authority		
Public	83.5%	0.83 (0.27)
Private	85.5%	0.86 (0.35)
Facility type		
Health Center	**80.5%**	**0.81 (0.40)**
Hospital	**93.4%**	**0.93 (0.25)**
Urbanicity		
Urban	86.1%	0.86 (0.35)
Rural	83.6%	0.84 (0.37)

Bold indicates a significant difference in association (p<0.05) by patient or facility characteristic.
*N=1827 patients at 360 facilities
**N=1848 patients at 360 facilities
***N=1826 patients at 360 facilities

4.4.3.1 *Intraclass correlation*

The intraclass correlation of the intended delivery location variable was 0.29 (95% CI: 0.21, 0.39), indicating that 29% of the variation in this variable could be attributed to facility level differences. This is above the cut-off of 0.10, indicating that a multilevel approach was warranted. Using the intraclass correlation and the average cluster size of 5.2, the design effect was calculated as 2.2, which also supports the need for the multilevel analysis.

4.4.4 **Model modifications**

In the model initially proposed in Chapter 3, certain variables were considered as covariates based on past research on patient satisfaction (See Table 3.11.). As described in Aim 2, one step of the exploratory data analysis was to assess the correlation of each of these candidate covariates with the others and remove one of any covariate pairs correlated at greater than 0.3. Of the three candidate facility level covariates, urbanicity was removed because its correlation with type of health facility ($\rho = 0.4$) exceeded the prescribed cut point. Facility type was retained and urbanicity was removed due to the stronger evidence of a link between type of health facility and patient satisfaction [6, 7].

None of the patient level candidate covariates were correlated with one another above the cut point.

4.4.5 **Hypothesis 3.1: All four quality of care indices - infrastructure, human resources, technical, and interpersonal - are positively and directly associated with intention to deliver at the same facility after controlling for other covariates.**

Of the 1857 women in this sample, 40 had missing data on independent variables. Therefore, the analytic sample included the 1817 women with complete data in 360 facilities.

In a similar approach to that used in Aim 2, the associations of the quality of care elements and covariates with intention to deliver at the same facility were tested in increasingly complex models. Results of the associations of facility level quality of care elements are discussed first, followed by other facility level covariates and patient level quality of care elements and covariates.

4.4.5.1 *Description of models tested*

In the first model, associations of each quality of care element and covariate individually with intention to deliver at the same facility were tested using simple logistic regression models.

In this simplest of models, each covariate is tested separately with intention to deliver at the same facility.

In the second model, the associations of each quality of care element and covariate individually with intention to deliver at the same facility were tested using bivariate logistic mixed models which account for the clustering of patients within facilities.

The third model tested associations of quality elements with intention to deliver at the same facility using a single multilevel path model which incorporated all four quality of care elements but no covariates. At the facility level, this approach tested both the direct paths from each of the four quality elements to intention to deliver at the same facility and also the indirect paths from infrastructure and human resources to intention to deliver at the same facility through technical and interpersonal process quality. At the patient level, this approach tested the direct paths from technical and interpersonal process quality to intention to deliver at the same facility.

The fourth and final model tested associations of quality elements with intention to deliver at the same facility derived from a single multilevel path model which incorporated all four quality of care elements and all patient and facility level covariates.

For model 1, standardized log odds, abbreviated lnOR, are reported. For models 2 and 3 standardized log odds are reported for the results of the patient level portion of the model, and standardized linear regression coefficients are reported for the facility level portion of each model [22]. For model 4, standardized log odds are reported for the continuous covariates at the patient level while unstandardized log odds are reported for the categorical covariates at the patient level, as appropriate for a binary outcome. Unstandardized log odds and regression coefficients are included in Appendix C.

Standardized coefficients are calculated by transforming all variables in the model to have a mean of zero and a standard deviation of one. Interpretation of standardized regression

coefficients was discussed in section 4.3.5.1. A standardized log odds for a continuous independent variable is standardized with respect to X only and indicates how much change there is in the log odds of a binary dependent variable, on average, for a one standard deviation change in the independent variable, expressed in terms of the standard deviation of the log odds of the dependent variable. In the case of binary independent variables with a continuous dependent variable, such as is the case here at the facility level, the standardized log odds is standardized with respect to Y only and indicates how much change there is in the log odds of the dependent variable, on average, when *x* changes from zero to one, expressed in terms of the standard deviation of the log odds of the dependent variable [9]. With binary independent variables and binary dependent variables, unstandardized log odds are most appropriate to report.

4.4.5.2 *Facility level quality of care associations with intention to deliver at the same facility*

Table 4.27 shows results of the models described in the previous section.

Column 1 shows that in separate simple logistic regression models, infrastructure (lnOR = 0.08, $p<0.05$), human resources (lnOR = 0.12, $p<0.05$), and facility average technical process (lnOR = 0.08, $p<0.05$) elements of quality of care were both significantly positively associated with patient satisfaction.

Column 2 shows that in separate logistic mixed regressions which account for clustering at the facility level, the associations of human resources quality with intention to deliver at the same facility is the only quality of care covariate which remains significant at $p<0.05$ ($\beta = 0.20$).

Column 3 shows results of the third model. In this model, at the facility level, none of the quality of care covariates are significant at $p<0.05$. The overall R^2 for the facility level model was 0.05, meaning that 5% of the variance in facility level intention to deliver at the same facility could be predicted from the facility level mean quality of care elements.

Column 4 shows that none of the facility level quality of care covariates had a significant association with intention to deliver at the same facility in the full multilevel path model. Figure 4.3 shows the facility level path model with the standardized path coefficients for Model 4. The overall R^2 for the facility level model was 0.34, so in this case 34% of the variance in facility level mean patient satisfaction could be predicted from the facility level mean quality of care elements and the other facility level covariates. Results for the other facility level covariates are discussed in the next section.

Table 4.27: Associations of quality of care elements and covariates with intended delivery location in increasingly complex models (N=1817, n=360)

	1	**2**	**3**	**4**
	Simple logistic regression models	Logistic mixed models	Simple ML path model	Full ML path model
Facility level				
	Standardized lnOR (SE)	Standardized β (SE)	Standardized β (SE)	Standardized β (SE)
Infrastructure	0.08 (0.04) **	0.13 (0.08) *	0.11 (0.08)	0.00 (0.08)
Human Resources	0.12 (0.03) **	0.20 (0.08) **	0.17 (0.09) *	0.08 (0.08)
Technical	0.08 (0.03) **	0.11 (0.09)	-0.04 (0.17)	-0.05 (0.17)
Interpersonal	0.05 (0.03)	0.06 (0.08)	0.09 (0.14)	0.11 (0.15)
Hospital (ref: Health Center)	0.62 (0.08) **	1.13 (0.19) **	NA	1.32 (0.20) **
Public (ref: Private)	-0.09 (0.08)	-0.17 (0.20)	NA	0.02 (0.19)
Density	-0.07 (0.03) **	-0.15 (0.08) *	NA	-0.10 (0.08)
			R^2=0.05	R^2=0.34
Patient level				
	Standardized lnOR (SE)	Standardized lnOR (SE)	Standardized lnOR (SE)	Standardized and unstandardized lnOR (SE)
Technical	0.09 (0.04) **	0.09 (0.05) *	0.06 (0.14)	0.04 (0.14)
Interpersonal	0.03 (0.03)	0.01 (0.05)	-0.11 (0.13)	-0.12 (0.13)
First ANC visit (ref: Not first ANC visit)	0.04 (0.07)	0.02 (0.09)	NA	0.10 (0.18)
Attended secondary school (ref: Did not attend secondary school)	-0.21 (0.08) **	-0.28 (0.09) **	NA	-0.57 (0.18) **
Multipara (ref: Primipara)	0.32 (0.08) **	0.33 (0.09) **	NA	0.60 (0.17) **

Closest facility to home (ref: Not nearest facility to home)	-0.03 (0.13)	0.07 (0.14)	NA	0.18 (0.28)
			R^2=0.00	R^2=0.05

*p<0.10; **p<0.05

Column 1 presents simple logistic regressions of intention to deliver at the same facility on each covariate separately. Associations are expressed as standardized logistic regression coefficients with standard error.

Column 2 presents multivariable logistic mixed model to account for clustering at the facility level. Facility level associations are expressed as standardized linear regression coefficients with standard error. Patient level associations are expressed as standardized logistic regression coefficients with standard error.

Column 3 includes direct effects of all quality elements on intention to deliver at the same facility and indirect effects of infrastructure and human resources on intention to deliver at the same facility through technical and interpersonal process. Facility level associations are expressed as standardized path coefficients with standard error. Patient level association are expressed as standardized logistic regression coefficients.

Column 4 includes all quality elements as in Column 3 and adds covariates[29]. Facility level associations are expressed as standardized path coefficients with standard error, patient level association are expressed as standardized logistic regression coefficients with standard error.

4.4.5.3 *Other facility level covariates*

Other non-quality of care facility level covariates included in the models had significant associations with intended delivery location. Facility type was a highly significant predictor throughout all of the models, with the largest effect size of any independent variable in the full multilevel path model. Column 4 showed that in the full multilevel path analysis, on average, women at hospitals had higher intention deliver at the same facility when compared with women at health centers ($\beta = 1.32$, p<0.001). While rare to have a standardized coefficient greater than 1, it is possible. Although not always the case, coefficients greater than 1 may be due to multicollinearity in the exogenous variables [23]. Multicollinearity of the exogenous variables was assessed; none of the exogenous variables were correlated above 0.4. Upon examination of

[29] Facility level covariates are level (hospital versus health center), operating authority (public versus private), and delivery facility density (number of labor and delivery facilities within a 10 km radius). Patient level covariates are number of antenatal care visits (First antenatal care visit versus later), education (attended secondary school versus not), parity (first pregnancy versus later pregnancy), and distance (attending antenatal care at the closest facility to home versus not).

the correlation matrix of the betas in the multilevel path model, it was found that there was multicollinearity of some betas, which may have contributed to the high coefficient.

Density, or the number of labor and delivery facilities within a ten-kilometer radius, was negatively associated with intention to deliver at the same facility in the simplest logistic regression model (lnOR = -0.07, $p<0.05$), but this association was attenuated in the more complex models.

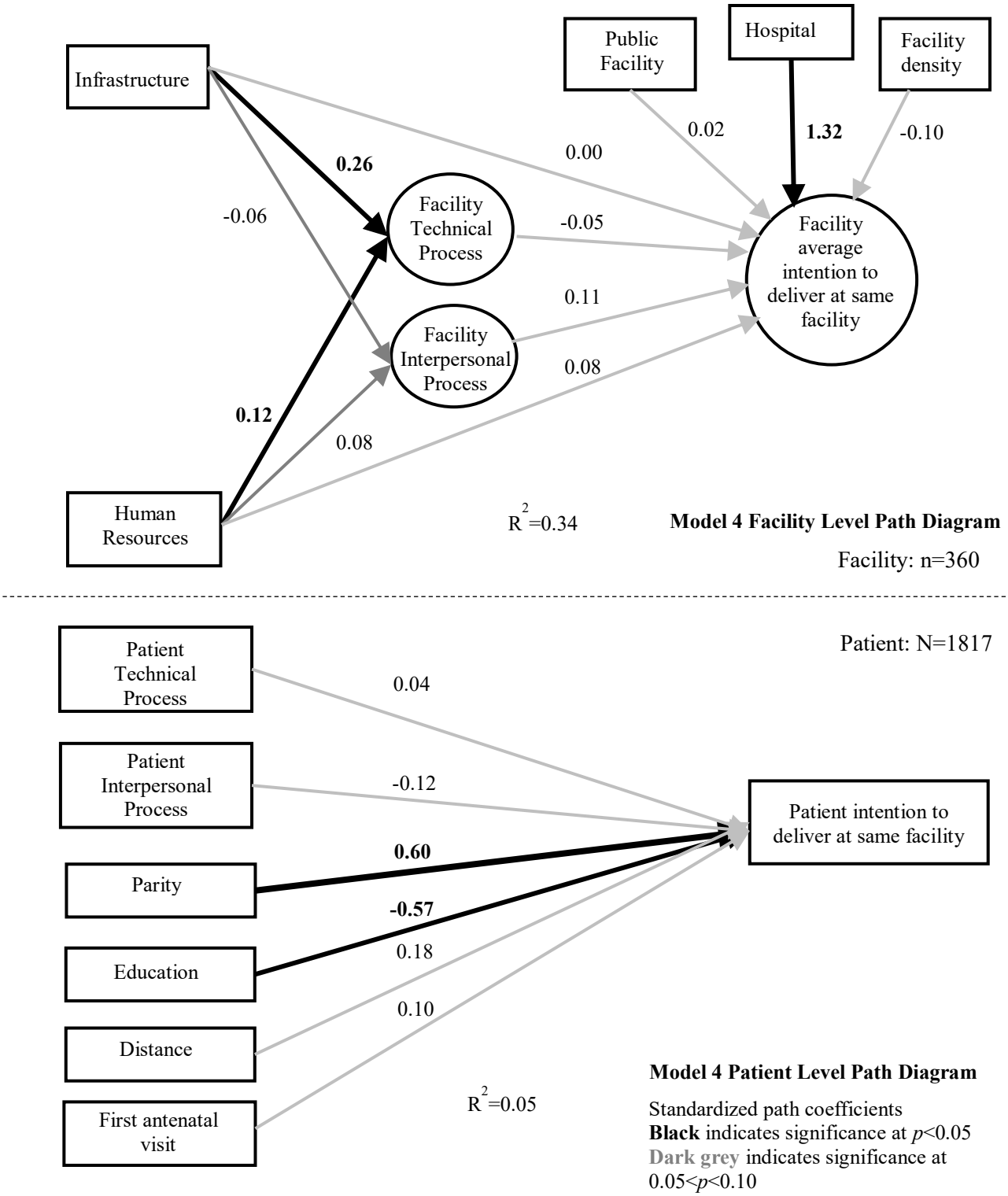
4.4.5.4 *Patient level covariates*

Two of the four patient level covariates were statistically significant predictors of a patient's odds of intending to deliver at the same facility. In models 1, 2, and 4, women who had attended any secondary school had lower odds of intending to deliver at the same facility when compared to women who did not attend secondary school, and the strength of this association grew with growing complexity of the models (Model 1: lnOR = -0.21, $p<0.01$, Model 2: lnOR = -0.28, $p<0.01$,Model 4: lnOR = -0.57, $p<0.01$). In models 1, 2, and 4, multiparous women had higher odds of intending to deliver at the same facility when compared with primiparas (Model 1: lnOR = 0.32, $p<0.001$, Model 2: lnOR = 0.33, $p<0.001$, Model 4: lnOR = 0.60, $p<0.001$).

Patient level covariates explained a negligible proportion of the variance in intention to deliver at the same facility

Figure 4.3 shows the facility and patient level coefficients for the full multilevel path model represented in model 4.

Figure 4.3: Model 4 multilevel path analysis with standardized coefficients. Facility and patient level models were fit simultaneously.



4.4.6 **Hypothesis 3.2: The two process quality indices – technical and interpersonal – mediate the association of the two structural quality indices – infrastructure and human resources – with intention to deliver at the same facility.**

Both of the structural measures of quality – infrastructure and human resources – were hypothesized to have indirect effects on intention to deliver at the same facility, through the two process quality measures – technical and interpersonal. Using the Monte Carlo 95% confidence interval method for assessing mediation, only one of the indirect effects hypothesized was significant. Infrastructure had a significant negative effect on intention to deliver at the same facility through the technical process. All other indirect effects were non-significant (See Table 4.28 and Table 4.29:). Coefficients included in Tables 4.28 and 4.29 differ slightly from those in Figure 4.3 and Table 4.27 as they are the unstandardized rather than the standardized path coefficients.

Table 4.28: Facility-level total, direct, and indirect effects of infrastructure on facility level intention to deliver at the same health facility

Infrastructure	Unstandardized path coefficient	Standard Error	Monte Carlo 95% CI
Total effect	-0.14		
Direct effect	0.00	0.62	
Indirect effect (through technical process)	**-0.09**	**0.34**	**(-0.18, -0.02)**
Indirect effect (through interpersonal process)	-0.05	0.08	(-0.15, 0.00)

Standard Errors were calculated in Mplus using the Sobel test[30].

Monte Carlo 95% confidence intervals for indirect effects were calculated using the Monte Carlo method for assessing mediation method as described in Chapter 3 [10].

Bold indicates significance (Monte Carlo 95% confidence interval does not include 0)

[30] The Sobel test, which is commonly used to test indirect effects, and which is calculated in Mplus, uses a z-test to test for significance of the indirect effect. However, z-tests assume that the indirect effects are normally distributed over repeated sampling, which is not true. Using the Monte Carlo method makes no assumptions about the distribution of the indirect effect and therefore yields confidence intervals which are faithful to the skewed sampling distributions of indirect effects.

Table 4.29: Facility-level total, direct, and indirect effects of human resources on facility level intention to deliver at the same health facility

Human Resources	Unstandardized path coefficient	Standard Error	Monte Carlo 95% CI
Total effect	0.7		
Direct effect	0.67	0.70	
Indirect effect (through technical process)	-0.05	0.19	(-0.10, 0.00)
Indirect effect (through interpersonal process)	0.08	0.13	(-0.03, 0.20)

Standard Errors were calculated in Mplus using the Sobel test.

Monte Carlo 95% confidence intervals for indirect effects were calculated using the Monte Carlo method for assessing mediation method as described in Chapter 3 [10].

4.4.7 **Sensitivity analyses**

4.4.7.1 *Including facilities with 2 or more observations*

Facilities with a single patient-provider observation were removed to better capture variation within versus between facilities. The results of hypothesis testing were similar when limiting the analysis to the 1810 patients at the 353 facilities with at least two patient-provider interactions. Only one association, of human resources with facility technical process quality, was originally significant (standardized $\beta = 0.12$, $p<0.05$), but was attenuated in this analysis (standardized $\beta = 0.11$, $p<0.10$).

4.4.7.2 *Accounting for observer bias*

With the 353 facilities with multiple patient observations, a sensitivity analysis was planned to drop the first observation to account for potential Hawthorne effect. However, as discussed in section 1.2.5.1, there were no significant differences in technical and interpersonal process scores including and excluding the first observations, therefore this analysis was not conducted.

4.4.7.3 *Group differences*

The associations of covariates with intention to deliver at the same facility were examined among different groups of facilities: public versus private facilities and hospitals versus health centers. Table 4.30 shows the differences in associations of each coefficient with intention to deliver at the same facility in each of the different groups of facilities. Mplus does not test for the statistical significance of differences in coefficients between models for binary outcomes.

Table 4.30: Facility and patient level associations of covariates with intention to deliver in the same facility in subsets of facilities (Public vs private, hospitals vs health centers). Standardized coefficients reported.

	Public N=1325 n=242	**Private** N=532 n=118	**Hospitals** N=513 n=85	**Health Centers** N=1344 n=275
Facility level				
Infrastructure	0.13 (0.08)	-0.01 (0.13)	0.01 (0.14)	-0.01 (0.10)
Human Resources	-0.14 (0.08) *	0.01 (0.16)	0.17 (0.18)	0.06 (0.09)
Technical	-0.13 (0.09)	0.13 (0.28)	-0.55 (0.26) **	0.12 (0.20)
Interpersonal	0.12 (0.08)	0.38 (0.23)	-0.30 (0.32)	0.28 (0.17)
Density	-0.02 (0.05)	-0.24 (0.14) *	-0.12 (0.17)	-0.09 (0.10)
Public	NA	NA	0.42 (0.30)	-0.10 (0.25)
Hospital	1.70 (0.28) **	0.95 (0.32) **	NA	NA
Patient level				
Technical	0.01 (0.03)	-0.02 (0.10)	0.19 (0.12) *	-0.02 (0.05)
Interpersonal	0.04 (0.04)	-0.03 (0.10)	0.27 (0.14) **	-0.10 (0.05) **
Education	-0.15 (0.12)	-0.75 (0.16) **	-0.27 (0.20)	-0.33 (0.11) **
Parity	0.36 (0.10) **	0.22 (0.18)	0.27 (0.24)	0.33 (0.10) **
First ANC	0.01 (0.11)	0.08 (0.19)	0.38 (0.25)	0.01 (0.10)
Distance	0.16 (0.18)	-0.28 (0.31)	-0.21 (0.34)	0.20 (0.17)

Asterisks indicate significance of the association of the covariate with intention to deliver ant the same facility. *p<0.10; **p<0.05

Coefficients at the facility level are standardized linear regression coefficients.
Coefficients at patient level are standardized log odds.

First, publicly managed facilities were compared with privately managed facilities. In both groups of facilities, the findings were similar to the overall model. In the overall model, education and parity were the only patient covariates significantly associated with intention to deliver at the same facility. However, when examining the model within private facilities only, education was the only patient level covariate significantly associated with odds of intending to

deliver at the same facility. Parity was no longer associated with patient level odds of intending to deliver at the same facility. For public facilities, parity was the only patient level covariate significantly associated with the odds of a woman intending to deliver at the same facility where she attended antenatal care. Education was no longer associated with patient level odds of intending to deliver at the same facility.

When health centers and hospitals were compared, different patterns of significant covariates emerged. In health centers, at the patient level, education and parity maintained significant associations with odds of intending to deliver at the same facility, however patient level interpersonal process quality had a significant negative association with odds of intending to deliver at the same facility. None of the facility level covariates had a significant association with patient satisfaction within health centers.

At hospitals, patient level interpersonal process quality had a significant positive association with odds of intending to deliver at the same facility, but none of the other patient covariates were significantly associated with odds of intending to deliver at the same facility. At the facility level, technical process quality had a significantly negative association with intention to deliver at the same facility, an association which had not been seen in any other models.

Mplus does not have the capability to test whether the difference in coefficients between groups (*e.g.* hospitals versus health centers) is statistically different from zero in the context of binary outcome variables.

4.4.7.4 *Cross-level interaction effects*

Given the large effect of two of the patient level characteristics – education and parity – and facility type, additional sensitivity analysis were conducted to evaluate whether the association between facility type and patient satisfaction differs by patient education and parity. Cross-level interactions between education and facility type, and parity and facility type, were

each modeled separately and tested for significance. Neither of these cross-level interactions were statistically significant at $p<0.05$, indicating that the patient level associations between education and odds of intending to deliver at the same facility, and parity and the odds of intending to deliver at the same facility do not differ significantly depending on facility type.

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Chapter 5: Discussion

5.1 OVERVIEW

This chapter presents the following: a brief overview of study aims and methods, a summary of study results and discussion of these results in turn, followed by a discussion of strengths and limitations, implications, and conclusions of the research.

5.2 OVERVIEW OF STUDY AIMS AND METHODS

This study applied the Donabedian framework for quality of care, in which good structure is posited to lead to good process which is posited to lead to good outcomes, using data from maternal health care in Malawi.

Aim 1 evaluated associations among four structure and process quality of care elements – infrastructure, human resources, technical process, and interpersonal process – first in antenatal care and then in labor and delivery care. It also evaluated associations between each quality of care element in antenatal care with its counterpart in labor and delivery care. Bivariate differences in quality by facility operating authority, type, and location were assessed with t-tests. Spearman's correlations were used to assess the strength of the associations between pairs of quality elements.

Aim 2 evaluated associations of the four quality of care elements with patient satisfaction. Analyses focused only on antenatal care, for which patient satisfaction had been measured. Patient satisfaction was assessed using an 11-item index. Bivariate differences in patient satisfaction and patient level quality of care measures were assessed using t-tests.

A multilevel path analysis was also conducted. The analysis controlled for patient characteristics of education, parity, distance from the health facility, first antenatal care visit, as well as facility characteristics of facility type and operating authority. Direct effects of the four quality of care elements on patient satisfaction were assessed, as well as indirect effects of

infrastructure and human resources on patient satisfaction as mediated through technical and interpersonal process quality.

Aim 3 evaluated associations of the four continuous quality of care elements with the binary outcome, intention to deliver at the same health facility. Bivariate associations of intended delivery location with facility and patient characteristics were assessed with chi-square tests for intended delivery location and t-tests for quality scores.

A multilevel path analysis was also conducted, which controlled for patient characteristics of education, parity, distance from the health facility, first antenatal care visit, as well as facility characteristics of facility type, operating authority, and delivery facility density. Direct effects of the four quality of care elements and intention to deliver at the same facility were assessed, as well as indirect effects of infrastructure and human resources on intention to deliver at the same facility as mediated through technical and interpersonal process quality.

5.3 SUMMARY OF STUDY RESULTS

The following were the main results of the analyses described above:

1. On average, structural and process quality was poor in both antenatal and labor and delivery care.
2. Structural quality was positively associated with technical process quality, more so for labor and delivery than for antenatal care and more so for infrastructure than for human resource aspects of structure.
3. Structural quality was not associated with interpersonal process quality.
4. Technical, but not interpersonal, process quality was correlated in the two service areas.
5. Patient satisfaction with antenatal care was high.
6. Structure and process quality measures, for the most part, were not associated with patient satisfaction with care.

7. Neither of the structural elements of quality had indirect effects on patient satisfaction through the process elements.
8. Facility and patient characteristics were more strongly associated with patient satisfaction than were structure and process quality measures.
9. Most women intended to deliver in the same facility where they received antenatal care.
10. Structure and process quality of care were not associated with maternal intention to deliver at the same facility where she received antenatal care.
11. Infrastructure had an indirect effect on maternal intention to deliver at the same facility through technical process quality.
12. Facility and patient characteristics were more strongly associated with maternal intention to deliver in the same facility than were structure and process indicators of quality of care.

5.4 DISCUSSION OF STUDY RESULTS

5.4.1 On average, structural and process quality was poor for both antenatal and labor and delivery care.

While describing the levels of quality was not an aim of this study, the findings warrant discussion. Structure – infrastructure and human resource – and process – technical and interpersonal – quality of care in antenatal and labor and delivery care was low, ranging from 0.43 for antenatal human resources quality to 0.69 for labor and delivery infrastructure quality (possible and actual range 0-1). In both service areas, human resources quality was the lowest, followed by technical process quality, then interpersonal process quality, with infrastructure quality the highest. Variability was high and consistent across the measures, with standard deviations between 0.12 and 0.16 for all quality scores.

These quality scores were concordant with maternal health care quality assessments in other sub-Saharan African countries, both in the level and the variability of quality score [1-4].

Results in this study also were aligned with previous research in finding higher scores for infrastructure compared to technical quality [3, 4].

Quality of care scores varied across facilities in ways that were consistent with previous research in sub-Saharan Africa. Privately operated facilities had better infrastructure and technical process quality of care when compared to public facilities [2, 5, 6]. Most privately operated facilities in this study were operated by the Christian Association of Malawi [7]; one study suggested that faith-based facilities provide higher quality care because they receive financial and in-kind support from religious groups and donors [8].

Hospitals had better infrastructure, human resources, and technical quality when compared to health centers [1, 2, 6]. Hospitals were more likely to be located in an urban area, thus closer to supply routes, allowing for faster replenishment of drugs and equipment. There are also generally fewer staff vacancies at hospitals [9]. Hospitals also receive higher volume of patients, which has been shown to be associated with higher technical quality [2].

Process quality also varied across subsets of patients. Technical quality of care was better for women at their first antenatal care visit as compared to women at a subsequent antenatal care visit. Previous findings on quality of care for first antenatal visit as compared to subsequent visits have been mixed, with one study reporting better care for the first antenatal care visit [10], and another reporting better care for the subsequent visits [11].

Technical quality of care was also better for women with more years of education. This is consistent with prior research in diverse settings [12, 13]. One possible reason is that higher patient education reduces the social distance between women and their health providers, potentially leading providers to give better quality care. A related reason is that patient with higher levels of education expect, and thus receive, higher quality services.

Women who bypassed their nearest facility for antenatal care received higher quality care as measured by process indicators. This finding is consistent with previous research showing that women in low- and middle-income countries (LMICs) are willing to bypass the nearest facility for maternal health services [14-20] and that they do so because they perceive care at the nearest facility to be poor [15-17, 19, 20]. These results indicate that pregnant women in Malawi may be seeking out, and finding, better technical or interpersonal quality for antenatal care.

Primiparous women had significantly higher interpersonal process quality in labor and delivery compared to multiparous women. Previous research on the prevalence of respectful maternity care, an analogous concept to good interpersonal quality, has been mixed. Two studies found no association between parity and respectful care [21, 22] while a third study, like this one, found higher quality of care for primiparous women [23]. Qualitative research has found that providers may have negative attitudes towards multiparous women, and may shame them about having too many children [24].

5.4.2 Structural quality was positively associated with technical process quality, more so for labor and delivery than for antenatal care and more so for infrastructure than for human resource aspects of structure.

Antenatal care infrastructure quality had a weak positive association with technical process quality, while in labor and delivery, infrastructure was moderately positively correlated with technical process quality. These findings were consistent with results of Leslie et al.'s study of correlations of infrastructure with observed clinical quality of care in nine LMICs, including Malawi [3]. Labor and delivery care is more resource-intensive than antenatal care, requiring more in the way of medications and equipment. For this reason, the slightly stronger association of infrastructure with technical process for labor and delivery versus antenatal care makes sense.

Human resource quality was only weakly correlated with technical process. This was surprising in light of empirical evidence that good human resource management motivates health

care providers [1, 25-29] and that more highly motivated health care providers provide higher quality services [30-32].

Two aspects of human resources quality measurement might have attenuated the expected association of human resources with technical process. First, several items in the human resources quality measure were scored as present only if all providers interviewed at the facility were positive for the item. However, measurement in the current study was limited to interviewed providers and for three-quarters of both antenatal and labor and delivery facilities, only one provider was interviewed. Thus, for most facilities, the measure of human resources quality was based on a single provider, which might have biased scores upward.

Second, the SPA instrument did not include items on one aspect of human resources management included in the WHO quality of care framework – provider motivation [33]. If the omitted items are, in fact, important determinants of process quality, their omission would have attenuated the current study's estimate of the association between human resources and process quality.

5.4.3 **Structural quality was not associated with interpersonal process quality.**

In this study, it was hypothesized that better work environment, such as with a better supply of medicine and equipment and more provider training, would motivate providers, as has been shown in research in other African countries [25, 26]; and that more highly motivated providers would deliver services with better interpersonal process quality. However, the findings did not support these assumptions.

Recently there has been a renewed focus on the concept of interpersonal care in maternal health, with more research in the comparable areas of respectful maternal care and person-centered maternal care. Some of this research has identified patient and facility determinants of interpersonal quality, such as patient wealth, employment, and marital status, as well as facility

type, operating authority, and existence of policy on interpersonal quality, but none have explored the links between human resources and interpersonal quality [28, 34-36]. An intervention in Kenya showed promise for improving respectful maternal care with human resource management improvements including provider training on respectful care, provider psychosocial support, and facility quality improvement but suggests that systemic change is necessary to maximize and sustain provider behavior change [28].

5.4.4 Technical, but not interpersonal, process quality was correlated in the two service areas.

Within the same facility, technical, but not interpersonal, process quality in antenatal and labor and delivery care were positively correlated, however only moderately. One previous study showed no consistent correlations between observed clinical quality in different service areas within health facilities [3]. Within a facility with a given level of infrastructure and human resource quality, it would be expected that technical quality would be more than moderately correlated across service areas, so this finding was surprising.

The lack of correlation between interpersonal quality in antenatal care and labor and delivery care was also surprising. Within a facility, the same midwives frequently provide services in both antenatal and labor and delivery care, so it was hypothesized that the level of interpersonal process quality would be similar across the two services. The lack of association in this study might arise from differences in the measures of interpersonal quality for antenatal versus labor and delivery care. In antenatal care, the interpersonal quality measure was heavily weighted toward the domain of patient-provider communication, with limited representation of the dignity and respect domain, and no items on the emotional support domain. In contrast, the labor and delivery measure was more uniformly weighted over the three domains.

5.4.5 **Patient satisfaction with antenatal care was high.**

In this study, patient satisfaction was very high. While high patient satisfaction seems inconsistent with low levels of structural and process quality, this pattern has been previously observed in LMICs [37].

There are at least three explanations for highly positively skewed patient satisfaction scores: low expectations regarding the structure and process of care, social desirability bias, and question framing.

Studies from Malawi and other LMICs have shown that many women have low expectations of quality of care [38-40], and low patient expectation of care is a good predictor of high patient satisfaction [37]. In the context of low observed quality of care, low expectations of care could contribute to the high levels of patient satisfaction observed in this study.

Second, social desirability bias may have led patients to provide misleadingly positive responses to patient satisfaction questions. If the patients in the study population were particularly prone to social desirability bias, this could have been an issue.

Finally, question framing can influence on the response. There are two primary considerations for question framing. First is whether the question is framed positively (*e.g.* the health facility was clean) or negatively (*e.g.* the health facility was dirty). Negatively framed questions result in significantly lower levels of satisfaction compared with positively framed questions [41]. The current study used neutrally framed satisfaction items and so this framing issue was unlikely to be have contributed to the observed high satisfaction scores. Rather, in this study, satisfaction items asked whether particular aspects of the services received, *e.g.* cleanliness of the health facility, were a problem during today's visit.

The other question framing consideration is whether the aspect of care being assessed is subjective or objective. Subjective aspects of care, *e.g*. how the staff treated you, have been

shown to be more subject to positive skew as compared to objective aspects of care, *e.g.* availability of medicines [42]. This pattern was observed in the responses to specific patient satisfaction items in this study as well: the two lowest scoring items were two objective measures – availability of medicines at this facility and hours of service at this facility – while the subjective measures had higher scores. The measure of patient satisfaction in this study combined seven subjective and four objective aspects of care, and therefore may have been subject to bias.

5.4.6 Structure and process quality measures, for the most part, were not associated with patient satisfaction with care.

Donabedian's quality of care framework implies that structural quality is positively associated with process quality which in turn is positively associated with outcomes [43]. His original description of the framework suggested partial mediation, such that structure is positively associated with process and outcomes, while process is positively associated with outcomes [44, 45]. In either case, one would expect a positive association among the structure, process, and outcome measures.

In this study, very little variability in patient satisfaction was explained by structure and process quality. This finding can be attributed to at least three possible causes. First, the issues of measurement and low overall variability in the patient satisfaction outcome described in the previous section may have contributed to this result.

Second, the observed nature of structure and process quality measurement may have played a role in the lack of association of the quality measures with patient satisfaction. In the present study, the structure and process quality of care measures were derived from independent observation rather than self-report. Generally speaking, associations of patient satisfaction with structure and process quality of care have been stronger when using perceived [46-51] versus observed measures of quality [52, 53].

There may be single source bias in studies using perceived quality measures. When constructs, in this case, structure, process, and outcome, are measured using the same source, that is the same individual, correlations between those constructs are apt to be stronger [54]. As noted earlier in this dissertation, a few studies have looked at associations of structure, process, and outcome, with mixed results. For example, two studies which found support for Donabedian's quality of care framework, one in an integrated chronic disease management program in South Africa, and one in hospitals in Sweden, used structure, process, and outcome data from the same sources [55, 56]. Single source bias could have led to the strength of these associations. Other studies which used different data sources for each of the structure, process, and outcome measures have mixed support for Donabedian's framework [57-60].

Finally, it may be the case that the magnitude of associations of structure and process quality with outcomes are dependent on the type of outcome. For example, independently observed measures of structure and process quality may support the Donabedian quality framework when assessing clinical outcomes, while perceived measures of structure and process quality only support the Donabedian quality framework with patient outcomes such as patient satisfaction. As mentioned in Chapter 2, one of the key characteristics of patient satisfaction is that it is an emotion grounded in the alignment of an individual's perceived experience with what was expected. As such, it is the *perception* of the quality of care that has the greatest potential for changing patient satisfaction [61]. This study used measures of quality derived from independent observations of patient-provider encounters, rather than patients' perceptions of those encounters. Independent observation and patient perceptions of technical quality are not consistently associated in LMIC [48, 62, 63].

Interpersonal process quality was the only quality element found to have a significant association with patient satisfaction. At least one study has found that measures of interpersonal process quality have been shown to be consistent across independent observation and patient self-

report [64] and this finding is concordant with previous literature showing a positive association between interpersonal process quality and patient satisfaction [65-68].

Interestingly, the association of interpersonal process quality with patient satisfaction was seen at the facility level, but not at the patient level. This pattern is commonly referred to as a "contextual" effect in multilevel models, where the aggregate of a person-level characteristic is related to the outcome even after controlling for the effect of the individual characteristic [69].

Contextual effects can have at least two interpretations. First, the independent variable may be important as a norm rather than an individual level characteristic. In this case, good interpersonal process quality received during a specific encounter with a provider does not influence a woman's patient satisfaction, but women who attend antenatal care at facilities which have overall higher interpersonal process quality are more satisfied. It could be that a facility's provision of good interpersonal care overall is a better predictor of satisfaction. This scenario would explain the discrepancy between individual and facility level interpersonal process quality and patient satisfaction.

Raudenbush and Bryk [69] also discussed contextual effects as possible result of poor measurement of the independent variable. For the study at hand, this would imply that short comings in the measurement of interpersonal process gave rise to this association of interpersonal quality with patient satisfaction at the facility but not the individual level.

As discussed earlier in this chapter, items in the antenatal interpersonal process index were primarily from the patient-provider communication domain, with few items from the dignity and respect domain, and no items on the emotional support domain. A recent study using an interpersonal process measure with more equal representation of all three domains found significant positive associations with patient satisfaction in antenatal care in Ethiopia [47].

However, the Ethiopia study also differed in that it used patient perceptions of these measures as opposed to observation of the patient-provider interaction.

5.4.7 Neither of the structural elements of quality had indirect effects on patient satisfaction through the process elements.

Path analysis made it possible to test whether process quality mediated the association of structural quality with patient satisfaction. No indirect effects were found. Infrastructure was significantly associated with technical process quality, but technical process quality had only a weak association with patient satisfaction. Interpersonal process quality was significantly associated with patient satisfaction, but structural quality was only weakly associated with interpersonal process quality.

These results suggest that focusing on structural quality alone is an inadequate strategy to promote patient satisfaction.

5.4.8 Facility and patient characteristics were more strongly associated with patient satisfaction than were structure and process indicators of quality of care.

Although the hypothesis focused on the association of the quality of care elements with patient satisfaction, it is important to note that facility characteristics had much larger associations with patient satisfaction than any of the quality of care measures.

First, patients at private facilities were significantly more satisfied with their antenatal care compared to patients at public facilities. The effect of private facility was over twice the size of the effect of interpersonal process quality on patient satisfaction. This difference in patient satisfaction at public *vs.* private facilities is similar to findings from other settings [53, 70-72]. This difference is frequently attributed to more prompt care and better interpersonal care at privately managed facilities [53, 71, 72].

The effect of receiving antenatal care at a hospital was even larger, at just under four times larger than the effect of interpersonal process quality on patient satisfaction. This finding

contradicts previous research from Sri Lanka which found that women were more satisfied with care in lower level centers compared to hospitals [73]. The finding from this study indicates that there is something about hospitals, above and beyond the structural or process quality of care provided, from which women are gaining satisfaction. One possible explanation is that women in Malawi have a higher level of trust in hospitals compared to health centers. Trust in the health facility has previously been associated with increased patient satisfaction [74].

Patient characteristics also had significant effects on patient satisfaction. Consistent with previous evidence, women who had never attended secondary school had higher patient satisfaction compared to those who had [48, 75, 76]. Past research has suggested that with more education, women may develop higher expectations of health care [77] and that those with less education are more accepting of the care they receive [78, 79].

5.4.9 Most women intended to deliver in the same facility where they received antenatal care.

Most women intended to deliver at the same health facility where they received antenatal care. Intention to deliver at the same facility can be understood as the outcome of two decisions: first, the decision to deliver at a facility or not, and second, the decision to deliver at the same or different facility from the antenatal care facility. In Malawi, over 90% of women deliver at a facility [80], so most of the variability in this measure would come from the latter decision point. Women who attended secondary school, who were pregnant for the first time, and who attended antenatal care at a health center were more likely to intend to deliver at a *different* facility than the one where they attended antenatal care.

These findings are in line with previous research which found that women with more education and who are pregnant for the first time have higher odds of delivering in a facility [81, 82], and of bypassing their closest primary care facility for childbirth [17, 19, 83].

5.4.10 Antenatal structure and process quality measures were not associated with maternal intention to deliver at the same facility.

This study measured future health care utilization as a pregnant woman's intention to deliver at the facility where she received antenatal care. The study found that antenatal care quality was not associated with intention to deliver at the facility providing antenatal care.

The lack of association could have been due to the observed nature of the quality of care measures, as was discussed earlier. Most of the studies which found an association between quality of antenatal care and facility delivery measured used perceived quality measures [84-86], although one study using observed measures of quality did find an association between quality of antenatal care and facility delivery [87].

The lack of association of antenatal care quality with intention to deliver at the same facility also could relate to how women choose their delivery facility. The study hypothesis was based on the assumption that women do choose whether to deliver at the facility in which they received antenatal care and that they base this choice on the quality of antenatal care received. It is possible that pregnant women in Malawi may view the quality of their antenatal care separately from the care they anticipate receiving in childbirth. Therefore, quality received during antenatal care may not be an important factor in the decision of where to deliver. They may select the location for antenatal care and delivery for reasons other than quality of care.

5.4.11 Infrastructure had an indirect effect on maternal intention to deliver at the same facility through technical process quality

Infrastructure had a significant positive association with technical quality and technical quality had a weak, non-significant negative association with intention to deliver at the same facility. Together this resulted in a case of "indirect only" mediation [88], where there is a significant indirect effect even when the two direct effects are non-significant. This result should be taken as exploratory as the analysis was not powered for identification of an indirect effect.

Surprisingly, the indirect effect was negative, suggesting that as facility antenatal care infrastructure improved, the proportion of women receiving antenatal care who intend to deliver there decreased. This finding contradicts previous studies which have found support for the partial mediation interpretation of Donabedian's quality framework [55, 56].

5.4.12 Facility and patient characteristics were more strongly associated with maternal intention to deliver in the same facility than were structure and process indicators of quality of care.

Overall, the effect of receiving antenatal care at a hospital on intention to deliver at the same facility was significantly positive and very large, even controlling for the quality of care elements. This finding points to unmeasured aspects of the hospital setting associated with women's intention to deliver. These unmeasured aspects could include patient trust in hospitals as compared to health centers. Trust in the health facility and its providers has been linked with facility delivery [89-91]. In Malawi, patient trust may be much higher in hospitals as compared to health centers.

At the patient level, this study found that women pregnant for the first time were less likely to intend to deliver at the same facility. Previous studies have also shown a positive association of parity with bypassing for childbirth [15, 17]. Women in their first pregnancy, without previous childbirth experience, may be more hopeful of finding a facility with better quality of care in which to deliver and so therefore be more likely to intend to deliver elsewhere. In contrast, women who have had more children, and therefore more interaction with the health care system, may have less confidence in the overall health care system and choose to remain at the same health facility because they do not think they care would be better elsewhere.

Women with higher levels of education have significantly lower odds of intending to deliver at the same facility. This finding, which is consistent with the one study which looked at bypassing in antenatal care [92], suggests that women with more years of education may have

higher expectations of care and may seek out care that better meets their expectations, as was discussed earlier regarding more educated women having lower patient satisfaction.

5.5 STRENGTHS AND LIMITATIONS

5.5.1 Strengths

The proposed study has several strengths. One strength is its focus on settings and services less-well studied in previous research. Systematic research on quality is scarce in LMIC, and this study is a contribution to that literature. Of the research that does focus on LMIC quality of care, most is focused on quality of labor and delivery care rather than antenatal care. In addition, much of the antenatal care literature focuses on attendance rather than structure and process quality of care [93].

The decomposition of the different elements of structure, into infrastructure and human resources, and process, into technical and interpersonal, quality of care is also a strength of this study. Recent maternal care quality frameworks have distinguished between infrastructure and human resource elements of structure and technical and process quality, but few studies have explored how these different elements are associated with each other, and then associated with quality outcomes.

The statistical approach is also a strength. First, the multilevel aspect of this study accounted for the hierarchical nature of the data. Most previous studies on antenatal care quality have either aggregated data to facility level or simply did not account for clustering in the data. Failure to account for clustering of patients at facilities can result in over-estimates of associations of process quality of care with patient outcomes such as patient satisfaction and future health care use intentions [94]. Discrepancies of the findings in the present study and previous work may be attributable to the differences in analytic approach.

Second, the current study's analytic methods allow for the testing of a multi-pathway model rather than a single pathway. The associations of structure and process quality with outcomes such as patient satisfaction and intended delivery location are likely complex. This complexity requires a statistical approach that can take that complexity into account. Most prior studies in maternal health care have only focused on direct effects of structure and process quality on patient outcomes, rarely testing mediating pathways as well. This study tested not only direct effects, but also mediating pathways.

A third strength is the study's use of the 2013-2014 Malawi SPA dataset. This dataset was derived from a census of all formal health facilities in Malawi, yielding a large facility- and patient-level sample for analysis. Additionally, the dataset included observational measures of the quality of patient-provider interactions, a rarely measured aspect of quality.

5.5.2 **Limitations**

Study limitations arise from its reliance on existing data and to the study design used. The use of existing facility assessment data had two main limitations. First, the subsample of antenatal and labor and delivery care facilities with complete data differed from those in the overall sample. Overall antenatal and labor and delivery facilities were more likely to be public rather than private, health centers rather than hospitals, in the Southern Region of Malawi rather than the Central or Northern Region, and in rural rather than urban areas. Antenatal facilities included in the analysis were more likely to be public rather than private facilities, to be hospitals rather than health centers, and to be in Southern Malawi rather than in the other two Regions. Labor and delivery facilities included in the analysis were more likely to be hospitals rather than health centers, to be in the Central or Southern Region than the Northern Region, and to be in urban rather than rural areas. These disparities indicate that the findings may be weighted towards urban hospitals and may not be generalizable to rural health centers.

Second, study analyses were limited to variables available in the SPA dataset. Certain variables which were included in the conceptual framework of this study were not included in the dataset. Three types of variables could have been improved and/or included. First, patient characteristics shown to be associated with patient satisfaction and future health care use were not present. This includes demographic information on the women, such as socioeconomic status, information on maternal health status or risk, and expectations of care. Second, actual subsequent healthcare utilization data would have been valuable to use as an outcome instead of the proxy intended delivery location. Finally, the patient satisfaction measure could have been improved. Ideally, the patient satisfaction measure would have addressed many if not all of the concerns discussed earlier, as well as have been tested for reliability and validity in LMIC [41].

Bias may have been present in the measurement of certain variables. Observer bias and the observer (Hawthorne) effect may have influenced the structure and process quality measures. However, sensitivity analyses were conducted to test for these biases and none were found. Social desirability bias has been reported as a challenge in exit interviews, particularly on the topic of patient satisfaction. While steps were taken to mitigate this bias; specifically, the creation of a patient satisfaction index from multiple indicators less vulnerable to bias rather than simply using the patient satisfaction question. The intended delivery location outcome may be susceptible to bias as well, insofar as women interpreted the question to be another assessment of satisfaction with the facility and feel compelled to report that they intended to deliver at the facility when this was not true.

The analytic approach had at least two limitations. First, the cross-sectional design and the structural equation model approach preclude inferences about causality. Structural equation model approaches do not test causality; arrows in the path model diagrams are based on hypotheses of associations which are in turn based on evidence and theory. Second, no competing

models were tested. Therefore, there may be multiple models that fit the data as well or better than the proposed model.

5.6 IMPLICATIONS

The study has implications for future programs, policy, and research regarding antenatal care and labor and delivery care in Malawi and other LMIC.

5.6.1 **Programmatic implications**

5.6.1.1 *There is a need to focus on the structural and process quality of maternal health care, not just access.*

In Malawi, the focus on improving access to maternal health services has resulted in nearly universal coverage of antenatal care; nearly all women in Malawi attend antenatal care at least once in their pregnancy. However, the low technical quality of care provided yields much lower levels of effective coverage, also called quality-corrected coverage. Quality-corrected coverage of antenatal care has been estimated at 28% [95].

Poor process quality of care has been attributed to lack of infrastructure and poor human resources, as described in this dissertation. This attribution has resulted in the implementation of process quality improvement interventions which focused on infrastructure and/or human resources improvements. However, as the findings of the present study suggest, infrastructure and human resources are only weakly to moderately correlated with technical process quality. Provider training paired with supervision is the only intervention that has been shown to effectively improve technical process quality [96]. Policy changes suggested to improve quality of maternal health care will be discussed in the policy implications section.

5.6.1.2 *The approach to measuring quality needs to be revised.*

As a part of focusing on quality includes revisiting how it is measured within programs. The most frequently employed health facility assessment tools in LMIC are the Service Provision Assessment (SPA) – used for this study – and the Service Availability and Readiness Assessment

(SARA) [33]. Data from these assessments are commonly used by programs to guide decision making, however the measures of quality included in these tools do not adequately reflect the new WHO quality of care framework [33]. While the infrastructure element is well covered in these tools, key aspects of motivation of human resources are missing, as well as valid measures of interpersonal process quality and patient experience of care [33, 97].

Measurement of interpersonal process quality in maternal care in particular is in need of advancement. The 2013 Malawi SPA is anomalous because it did not use the standard observation tool for labor and delivery. Instead, it used a Quality of Care assessment tool developed by the Maternal and Child Health Integrated Project (MCHIP) [98]. This tool included detailed questions on the seven most common disrespectful practices during childbirth [99] and is more reflective of the WHO quality of care framework than is the standard SPA observation tool [100]. While many of the interpersonal quality items used in the MCHIP labor and delivery observation tool could be directly applied to antenatal care, there is a need to develop questions which apply specifically to antenatal interpersonal quality of care, as suggested by previous research [101]. Potential questions could also be adapted from the burgeoning field of patient-centered care [34, 102].

5.6.1.3 *There is a need to implement interventions to improve interpersonal process quality*

In addition to better measurement, specific interventions are needed to improve interpersonal process quality in maternal health care. Interpersonal process quality was the only quality element to be significantly associated with patient satisfaction, but its overall level was low. As will be discussed in the research implications section, future research is necessary to identify determinants of good interpersonal quality and transform those findings into interventions.

Certain intervention areas have shown promise for improving interpersonal communication. These include: incorporation of interpersonal elements in pre-service and in-service trainings; values and attitude clarification exercises for health providers; and changing dynamics within health facilities to foster respect and raise awareness among client population of their rights as patients [103]. These interventions could already be incorporated into maternal health programs.

5.6.2 **Policy implications**

5.6.2.1 *Maternal health services may need to be fundamentally reorganized to improve quality.*

In both antenatal and labor and delivery care, all four elements of quality of care had low to moderate average scores. This points to a need to focus not only on expanding access and coverage to antenatal and labor and delivery care but also to apply significant efforts to the improvement of the quality of care. The Lancet Global Health Commission on High Quality Health Systems recently recommended a "quality focused system redesign" that would have most antenatal care shift to primary health care facilities, such as health centers, and have all women give birth at hospitals [37]. This redesign would allow for health care personnel at each level to focus on provision of the appropriate kind of care for their level: preventive care such as routine antenatal care and treatment of stable conditions at the primary level, and acute or chronic conditions with higher risk of mortality or severe morbidity, such as high -risk antenatal care and all labor and delivery care at the hospital level.

As previously mentioned, the recent report from the Lancet Global Health Commission on High Quality Health Systems recommends a health system redesign to improve quality of health care across the health system. This redesign would seek to "efficiently maximize health outcomes and user confidence, rather than only geographic access to clinics" [37]. Antenatal care, and other preventive care services, would be provided at the primary health care level, while labor and delivery services would all be shifted to hospitals with surgical and specialized

newborn care services. The authors of the Lancet reports explored the implications of this redesign by modeling quality of care received as well as access using SPA data from Malawi and other countries. They found that for women in labor and delivery, this redesign would result in more women receiving better technical quality of care, with about the same level of interpersonal care, and with minimal increases in the percentage of women living 2 hours or more from a delivery facility [37].

The same modeling exercise should be undertaken for antenatal care. While there would likely be no significant increases in percentage of women living 2 hours away from an antenatal care facility, given the recent focus on increasing antenatal care access, there may be significant decreases in the quality of care women receive. In this study, quality of antenatal care infrastructure, human resources, and technical process was significantly poorer at health centers than at hospitals. Shifting all antenatal care to primary health care facilities, i.e. health centers, without a concerted effort to improve quality of care as a preliminary step, would result in pregnant women getting worse technical care.

In addition, prior to implementing this health system redesign, decision-makers would need to learn more about where women choose to attend antenatal care. The findings of this study suggest that some women bypass lower level health facilities in search of higher quality antenatal care. In this context, it may be challenging to require women to attend antenatal care at the facility closest to their home. Engaging these women and building their trust in the quality of care at the primary health care level will be necessary as a preliminary step to any health system redesign.

Therefore, while the results of this study provide additional evidence to support the recommendations of the Lancet Global Health Commission on High Quality Health Systems, they also suggest potential challenges in implementing this redesign.

5.6.3 **Research implications**

This study has raised three primary areas for future research.

5.6.3.1 *Identify drivers of and develop interventions to improve interpersonal quality.*

There is a need for research to identify the drivers of interpersonal quality. This study found that interpersonal quality was significantly associated with patient satisfaction but that average levels of interpersonal quality of care were low in both antenatal and labor and delivery care. These findings point to the importance of interpersonal care in the patient experience of care and the need to identify its drivers. In the present study, infrastructure and human resources quality were thought to influence interpersonal process quality by improving provider motivation. Those associations were not found in either antenatal or labor and deliver care. However, the SPA dataset did not include key measures of provider motivation in order to test this mechanism [33]. Therefore, additional research on drivers of interpersonal quality should include measures of provider motivation.

5.6.3.2 *Estimate proportions and determinants of women bypassing for antenatal care.*

The present study found that about nine percent of women bypassed their closest health facility for antenatal care. Bypassing for childbirth has been explored in many contexts [16, 17, 19, 20, 83] but bypassing for antenatal care has been studied only in urban Kenya [92]. More research is needed to estimate the prevalence, timing, and drivers of bypassing for antenatal care.

5.6.3.3 *Explore how perceptions of quality are shaped from observed quality.*

The present study found no evidence of associations of most structure and process quality measures with either patient satisfaction or intention to deliver at the same facility, despite previous evidence to the contrary. This contradiction may be due to the observed measurement of quality in the present study as compared to perceived measures used in most previous studies. Perceived quality of care may in fact be more important for these outcomes than observed quality.

If this is true, it would be important to better understand how patient perceptions of quality are shaped from actions of the providers. Sofaer and Firminger have developed a conceptual framework for the development of patient perceptions of quality of health services, but it focuses on the patient characteristics associated with *expectations* of quality [61]. Future research could provide valuable insight into how patient perceptions of the quality of care received are associated with measures of observed quality.

5.7 CONCLUSION

This study aimed to advance understanding of how four structure and process quality elements – infrastructure, human resources, technical process, and interpersonal process – were associated with each other and how they were associated with patient satisfaction and care seeking intentions in maternal health care. Structural and process quality of care in antenatal and labor and delivery care were low and variable. Technical process quality of care was weakly to moderately associated with structural elements of quality, while interpersonal process quality was not associated with either structural element. Only interpersonal process quality was a predictor of patient satisfaction. None of the quality of care elements predicted intention to deliver at the same health facility where a woman attended antenatal care. The findings also showed that facility characteristics are the greatest predictor of patient satisfaction and intention to deliver at the same location.

Strategies to improve maternal health outcomes are increasingly focused on improving the quality of care women receive rather than solely increasing access to and utilization of maternal health care. This study adds to the body of research on the levels and predictors of antenatal quality of care. Its findings suggest that the classic Donabedian quality of care framework may not be borne out when assessing patient outcomes such as patient satisfaction and future health care intentions. Maternal health care researchers need to explore what measures of quality may drive satisfaction and intention – observed or perceived quality of care. At times it is just as

important to show what associations do not exist when the assumption is that they do. The findings of this dissertation ultimately lead to more questions which may guide future research into effective approaches to improving maternal health structure and process quality and the outcomes of patient satisfaction and future health care utilization.

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Appendix A

A.1 Availability of each potential items in the SPA dataset, definition in the SPA dataset, categorization according to this study's definition of the quality element, and univariate distribution (Antenatal and labor and delivery)

Potential antenatal infrastructure quality measure items from the SARA by category, their availability in the SPA dataset, definition with question number in the SPA facility assessment, and univariate distribution in 400 facilities

Potential items from SARA	In SPA dataset	Definition	N	Proportion of facilities		
				Yes	No	Missing
1. Availability and functionality of water, energy, sanitation, hand-washing, and waste-disposal facilities						
Adequate power	Yes	Available electricity always available (340 AND 341) or functional generator with fuel/charged battery (343 AND 345 AND 346)	398	34.2%	65.8%	0.5%
Running water in ANC room	Yes	Visual confirmation of water in ANC room (1450.01)	393	79.9%	20.1%	1.8%
Adequate sanitation facilities	Yes	Functioning latrines for clients (620)	400	98.3%	1.8%	0.0%
Adequate communication systems	Yes	Available functioning phone (312 OR 315) or short-wave radio (318)	400	80.3%	19.8%	0.0%
Available computer with internet access	Yes	Available functioning computer with email/internet access (322 and 323)	365	23.6%	76.4%	8.8%
Emergency transport	Yes	Included in technical table				
Safe disposal of sharps available	Yes	ANC exam room has sharps container (1451.06)	400	87.3%	12.8%	0.0%
Safe disposal of infectious waste available	Yes	ANC exam room has waste receptacle (1451.04)	400	43.3%	56.8%	0.0%
Available disinfectant in ANC exam room	Yes	ANC exam room has disinfectant (1451.08)	400	58.5%	41.5%	0.0%
Available soap and running water or alcohol-based hand rub in ANC exam room	Yes	ANC exam room has soap and running water (1451.01 AND 1451.02) or alcohol-based hand rub (1451.03)	400	53.8%	46.3%	0.0%
2. Work areas which facilitate the provision of services						
Auditory and visual privacy	Yes	Included in interpersonal table				
Guidelines for standard precautions available	Yes	Observed available guidelines for standard precautions in ANC room (1451.13)	400	39.8%	60.3%	0.0%
Guidelines for ANC available	Yes	Observed available ANC guidelines (1410)	400	38.5%	61.5%	0.0%

Visual job aids available	Yes	Observed available visual aids for client education (1415)	400	53.0%	47.0%	0.0%
Staff trained in ANC	Yes	Included in human resources table				
Consultation table available for ANC	Yes	Observed available consultation table (1421.07)	400	39.8%	60.3%	0.0%
At least 5 days/week of ANC service provided	Yes	ANC offered 5 days per week or more (1401)	400	45.8%	54.3%	0.0%
Exam light available in ANC	Yes	Observed available and functioning exam light (1421.04)	400	24.8%	75.3%	0.0%
3. Adequate stock of medicines, supplies, and equipment.						
Latex gloves available	Yes	Observed available disposable gloves (1451.07)	400	86.0%	14.0%	0.0%
Blood pressure cuff/apparatus available	Yes	Observed available and functioning digital or manual BP apparatus (1421.01 OR 1421.02)	400	72.3%	27.8%	0.0%
Rapid hemoglobin test available	Yes	Observed available and valid or available elsewhere in facility (1406.04)	400	9.8%	90.3%	0.0%
Urine protein test available	Yes	Observed available and valid or available elsewhere in facility (1406.02)	400	8.0%	92.0%	0.0%
Iron or folic acid or combination tablets available	Yes	Iron or folic acid or combination tablets observed or reported available in ANC (1422)	400	92.5%	7.5%	0.0%
Tetanus toxoid vaccine available	Yes	Observed available and valid SP/Fansidar for IPTp (1422.04)	400	70.5%	29.5%	0.0%
IPTp drug available	Yes	Observed available and valid tetanus toxoid vaccine (1422.05)	400	98.5%	1.5%	0.0%
Insecticide treated bed nets available	Yes	Observed available and valid ITNs (1422.06)	400	76.5%	23.5%	0.0%
Scale available in ANC	Yes	Observed available and functioning adult weighing scale (1421.06)	400	89.8%	10.3%	0.0%
Fetoscope available in ANC	Yes	Observed available and functioning fetoscope (1421.05)	400	98.0%	2.0%	0.0%
Speculum available in ANC	No					
Stethoscope available in ANC	Yes	Observed available and functioning stethoscope (1421.03)	400	72.8%	27.3%	0.0%
Blank individual records available for ANC	Yes	Observed at least one blank copy of client health passport, health card, or record (1418)	400	36.3%	63.8%	0.0%
Thermometer available in ANC	No					

Potential antenatal human resources quality measure items from the WHO QoC Framework by category, their availability in the SPA dataset, definition with question number in the SPA health worker questionnaire, and univariate distribution in 400 facilities

Potential items from WHO QoC Framework	In SPA dataset	Definition	N	Proportion of facilities		
				Yes	No	Missing
1. Availability of staff						
24-hour availability of staff	Yes	Is there a health care worker present at the facility at all times? (300) + AND Is there a duty schedule or call list for 24-hour coverage? (301 AND 302) +	400	41.3%	58.8%	0.0%
Up-to-date staffing policy	No					
On display roster	Yes	Combined with 24-hour availability of staff				
Triage and waiting time policy	No					
Are all posts in health facility filled	No					
Are all staff oriented to their functions, roles, and responsibilities	No					
All women who attend the facility for maternal health care receive attention within the appropriate time for their condition	No					
Clear communication channels to reach staff	No					
2. Appropriate skills and competencies of health staff						
Continuing professional development program	No					
Procedures and plans for recruitment, deployment, motivation, and retention of staff	Yes	All ANC providers interviewed report existence of opportunities for promotion in your current job (805)	400	32.0%	68.0%	0.0%
		All ANC providers interviewed report receiving salary supplement (806)	400	87.0%	13.0%	0.0%
		All ANC providers interviewed report receiving any non-monetary incentives (807)	400	74.5%	25.5%	0.0%
Periodic performance appraisal	Yes	All ANC providers interviewed report receiving 1+ supervision with performance appraisal in the past six months (801 AND 802 AND 803.03)	400	66.3%	33.8%	0.0%
Sufficient numbers of educated, competent staff	Yes	All ANC providers interviewed report working 40 or fewer hours per week (800)	400	21.0%	79.0%	0.0%
Enabling, supportive environment	No					
Inter-professional collaborative practice	No					
Staff have a written job description	Yes	All ANC providers interviewed report having a written job description (804)	400	10.0%	90.0%	0.0%
Staff have received in-service training in last 12 months	Yes	All ANC providers interviewed report receiving training or training updates on ANC topics in past 2 years (502)	400	22.5%	77.5%	0.0%

Staff have received supervision in past 3 months	Yes	All ANC providers interviewed report receiving 1+ supervision visits in past six months (801-803)	400	76.0%	24.0%	0.0%
Staff have been assessed at least once in past 12 months	No					
Team meetings held to review competences and quality improvement activities	Yes	Does this facility routinely carry out quality assurance activities? AND Are there any official record of these activities? (440-441) +	400	14.6%	85.4%	0.0%
Staff interact with professional mentors to ensure clinical competence and improve performance	No					
Staff are engaged in quality improvement team meetings	No					
3. Managerial and clinical leadership through meetings and quality assurance						
Quality improvement plans	No					
Leadership structure	No					
Quality improvement team	No					
Regular collection of patient and provider satisfaction data	Yes	Does this facility have any system for determining clients' opinions about the health facility or its services (430) +	400	50.5%	49.5%	0.0%
At least one monthly meeting to review data, monitor quality improvement performance, make recommendations to address any identified problems	Yes	Does this facility routinely conduct maternal and/or neonatal death audits? (1617 AND 1618) +	360	46.4%	53.6%	10.0%
		Does this facility have routine facility management meetings? (410) +	400	65.8%	34.3%	0.0%
Accessible procedures and policies	No					
At least two annual meetings with stakeholders to review performance	Yes	Are there any routine meetings about facility activities with facility staff and community members (417-418) +	393	21.1%	78.9%	1.8%
Facility leaders trained in leadership and management	No					
Procedure for staff feedback to facility management	No					
Health facility leaders communicate the performance of the facility through established mechanisms for monitoring to all relevant staff	No					

Proportion of monthly meetings on the quality of care that were actually held in the preceding 12 months	No	

[+] Item is from facility assessment

Potential antenatal technical process quality items from the Malawi Focused Antenatal Care Guidelines by category, their availability in the SPA dataset, definition with question number in the SPA antenatal care observation tool, and univariate distribution in 2043 patients

Potential items from Malawi Focused Antenatal Care Guidelines	In SPA dataset	Definition	N	Proportion of women who received action		
				Yes	No	Missing
1. Evidence-based practices						
Takes client history	Yes	Observed questions on age, current medications, whether this is first pregnancy, LMP (104.01 AND 104.02 AND 104.03 AND 104.04)	2043	3.8%	96.2%	0.0%
Check weight	Yes	Observed done (107.01)	2043	76.0%	24.0%	0.0%
Check height	Yes	Observed done (107.12A)	2043	5.4%	94.6%	0.0%
Check edema	Yes	Observed done (107.04)	2043	64.4%	35.6%	0.0%
Breast exam	Yes	Observed done (107.10)	2043	39.5%	60.5%	0.0%
Check pallor for anemia	Yes	Observed done (107.03)	2043	78.9%	21.1%	0.0%
Check fundal height	Yes	Observed done (107.07)	2043	38.2%	61.8%	0.0%
Check fetal heart beat	Yes	Observed done (107.08)	2043	80.7%	19.3%	0.0%
Blood pressure	Yes	Observed done (107.01)	2043	54.6%	45.4%	0.0%
Hemoglobin test	Yes	Hemoglobin test performed or referred (108.01)	2043	3.6%	96.4%	0.0%
Syphilis test	Yes	Syphilis test performed or referred (108.04B OR C)	2043	4.9%	95.1%	0.0%
HIV test	Yes	HIV test performed or referred (109.04 OR 109.05)	2043	28.7%	71.3%	0.0%
Blood group testing	Yes	Blood group testing prescribed or given (108.02B or C)	2043	0.7%	99.3%	0.0%
Test urine for protein	Yes	Urine test for protein prescribed or given (108.03B OR C)	2043	0.7%	99.3%	0.0%
Tetanus toxoid vaccination	Yes	Tetanus toxoid vaccination prescribed or given (112.01)	2043	28.4%	71.6%	0.0%
Iron and folate	Yes	Iron and folate prescribed or given (111.01)	2043	86.0%	14.0%	0.0%
IPTp	Yes	IPTp prescribed or given (114.01 OR 114.02)	2043	63.0%	37.0%	0.0%
Assess significant symptoms:		Provider asked about any of these significant symptoms (ANY of 106.01-106.09)	2043	47.8%	52.2%	0.0%
Persistent cough	Yes	Provider asked about 3 or more of these significant symptoms (Three or more of 106.01-106.09)	2043	15.9%	84.1%	0.0%
Fetal movement	Yes					
Bleeding	Yes					
Swelling	Yes					
Fever	Yes					
Fatigue	Yes					
headache or blurred vision	Yes					
Counsel on pregnancy danger signs:		Included in interpersonal table				
Bleeding	Yes					

Swollen face or hands	Yes					
Fever	Yes					
Fatigue	Yes					
Headache	Yes					
Counsel on birth and emergency plan	Yes					
Counsel on process of pregnancy and its complications	Yes					
Counsel on use of drugs during pregnancy	Yes					
Counsel on harmful habits (smoking, drugs, alcohol)	Yes					
Counsel on nutrition	Yes					
Counsel on personal hygiene	Yes					
Counsel on rest and exercise during pregnancy	Yes					
Counsel on effects of STIs/HIV	Yes					
Counsel on infant feeding (Exclusive breastfeeding)	Yes					
Counsel on importance of colostrum, early initiation of breastfeeding	Yes					
Counsel on postpartum/postnatal care	Yes					
Counsel on pregnancy spacing (postpartum family planning)	Yes					
Counsel on symptoms/signs of labor	Yes					
Counsel on importance of antenatal care and schedule of routine visits	Yes					
2. Functional referral systems						
Emergency transport system	Yes	Functional ambulance with fuel observed (450 AND 451 AND 453) +	2043	32.6%	67.4%	0.0%
3. Information systems						
Functional system for collecting health services data	Yes	Does the facility have a system in place to regularly collect health services data and reports on it at least quarterly? (460 AND 461 AND 462) +	2043	97.2%	2.8%	0.0%

+ Item from the facility assessment applied to individual level

Potential antenatal interpersonal process quality measure items from the WHO QoC Framework by category, their availability in the SPA dataset, definition with question number in the SPA questionnaire, and univariate distribution in 2043 patients

Potential items from WHO QoC Framework	In SPA dataset	Definition	N	Proportion of women who received action		
				Yes	No	Missing
1. Effective provider-patient communication						
All women who attend antenatal care should receive written and verbal information and counselling	Yes	Used visual aids (118)	2036	9.0%	91.0%	0.3%
		Counselled on importance of 4 ANC visits (110.03)	2043	18.0%	82.0%	0.0%
		Counseled on any danger signs (106.01B-106.08B)	2043	45.8%	54.2%	0.0%
		Counselled on at least 1 aspect of birth preparation (115.01-115.05)	2043	74.0%	26.0%	0.0%
All women who attend antenatal care are given the opportunity to discuss their concerns and preferences	Yes	Asked if client has any questions (117)	2042	80.3%	19.7%	0.0%
All health care staff in antenatal care demonstrate the following skills: active listening, asking questions, responding to questions, verifying the understanding of women and their families and supporting women in problem-solving.	Yes	Informed patient about progress of pregnancy (110.02)	2043	61.4%	38.6%	0.0%
All women attending antenatal care have their pregnancy progress documented in their health card	Yes	Wrote on client card (120)	2043	99.6%	0.4%	0.0%
All women receiving antenatal care at the facility should have been introduced to the health facility staff and show good knowledge of the women's history and the care the care that had been given to date.	Yes	Looked at client card (119)	2042	99.9%	0.1%	0.0%
2. Patients treated with respect and dignity						
All procedures which require patient consent have a written record of consent	No					
All women who attend antenatal care receive care in a private space	Yes	Visual and auditory privacy in ANC room (1452) [+]	2043	96.2%	3.8%	0.0%
All women who attend antenatal care receive respectful, non-discriminatory services	No					
All women who attend antenatal care feel adequately informed by health staff regarding decisions taken about their care	No					
All women who attend antenatal care were aware that they had the right to accept or refuse treatment.	No					

[+] Item from the facility assessment applied to individual level

Potential labor and delivery infrastructure quality measure items from the SARA by category, their availability in the SPA dataset, definition with question number in the SPA facility assessment, and univariate distribution in 219 facilities

Potential item from SARA	In SPA dataset	Definition	N	Proportion of facilities		
				Yes	No	Missing
1. Availability and functionality of water, energy, sanitation, hand-washing, and waste-disposal facilities						
Adequate power	Yes	Available electricity always available (340 AND 341 response 1) or functional generator with fuel/charged battery (343 AND 345 response 1 AND 346 response 1)	219	38.8%	61.2%	0.0%
Running water in delivery room	Yes	Visual confirmation of water in labor and delivery room (1651.01)	218	96.8%	3.2%	0.5%
Adequate sanitation facilities	Yes	Functioning latrines for clients (620)	219	98.6%	1.4%	0.0%
Adequate communication systems	Yes	Available functioning phone (312 or 315) or short-wave radio (318)	219	87.2%	12.8%	0.0%
Available computer with internet access	Yes	Available functioning computer with email/internet access (322 and 323)	201	30.8%	69.2%	8.2%
Emergency transport	Yes	Included in technical index				
Safe disposal of sharps available	Yes	Labor and delivery room has sharps container (1651.06)	219	97.3%	2.7%	0.0%
Safe disposal of infectious waste available	Yes	Labor and delivery room has waste receptacle (1651.04)	219	48.4%	51.6%	0.0%
Available disinfectant in delivery room	Yes	Labor and delivery room has disinfectant (1651.08)	219	88.1%	11.9%	0.0%
Available soap and running water or alcohol-based hand rub in delivery room	Yes	Labor and delivery room has soap and running water (1651.01 and 1651.02) or alcohol-based hand rub (1651.03)	219	78.5%	21.5%	0.0%
2. Work areas which facilitate the provision of services						
Auditory and visual privacy	Yes	Included in interpersonal index				
Guidelines for standard precautions available	Yes	Observed available guidelines for standard precautions in labor and delivery room (1651.13)	219	65.8%	34.2%	0.0%
Guidelines for LD available	Yes	Observed available guidelines for standard precautions in labor and delivery room (1605 AND 1606)	219	45.2%	54.8%	0.0%
Staff trained in LD	Yes	Included in human resources index				
Delivery bed available	Yes	Observed available delivery bed (1623.01)	219	98.6%	1.4%	0.0%
Exam light available in LD	Yes	Exam light available and functioning (flashlight is ok) (1622.03)	219	34.7%	65.3%	0.0%
3. Adequate stock of medicines, supplies, and equipment.						

Latex gloves available	Yes	Observed available disposable gloves (1651.07)	219	98.6%	1.4%	0.0%
Sterilization equipment	No					
Delivery pack (or cord clamp, episiotomy scissors, scissors/blade to cut cord, suture material with needle, AND needle holder)	Yes	Observed available delivery pack (1623.02)	219	92.7%	7.3%	0.0%
Suction apparatus	Yes	Observed available and functioning suction apparatus (1622.04)	215	20.9%	79.1%	1.8%
Manual vacuum extractor	Yes	Observed available and functioning manual vacuum extractor (1622.06)	219	52.5%	47.5%	0.0%
Vacuum aspirator or D&C kit	Yes	Observed available and functioning vacuum aspirator or D&C kit (1622.07)	219	32.9%	67.1%	0.0%
Neonatal bag and mask	Yes	Observed available and functioning newborn bag and mask (1622.08)	219	92.2%	7.8%	0.0%
Partograph	Yes	Observed available partograph (1623.16)	219	98.6%	1.4%	0.0%
Infant weighing scale	Yes	Observed available and functional infant weighing scale (1622.11)	219	94.5%	5.5%	0.0%
BP apparatus	Yes	Observed available and functioning blood pressure apparatus (1622.13 OR 1622.14)	219	80.4%	19.6%	0.0%
Antibiotic ointment for newborn (tetracycline)	Yes	Observed available and valid antibiotic ointment for newborn (1625.01)	219	93.6%	6.4%	0.0%
Injectable antibiotic (ceftriaxone)	Yes	Observed available and valid injectable antibiotic (1625.02)	219	70.8%	29.2%	0.0%
Injectable uterotonic (oxytocin)	Yes	Observed available and valid injectable uterotonic (1625.03)	219	97.3%	2.7%	0.0%
Injectable Magnesium Sulfate	Yes	Observed available and valid injectable magnesium sulfate (1625.04)	219	94.5%	5.5%	0.0%
Gentamicin injection	No					
Ampicillin powder for injection	No					
Hydralazine injection	Yes	Observed available and valid hydralazine injection (1625.09)	219	32.9%	67.1%	0.0%
Metronidazole injection	No					
Azithromycin capsule/tabs or oral liquid	No					
Cefixime capsule/tabs	No					
Benzathine benzylpenicillin powder for injection	No					
Nifedipine capsule/tab	No					
Methyldopa tablet	No					
Calcium gluconate injection	No					
Sodium chloride injectable solution	No					
Betamethasone injection	No					
Dexamethasone injection	No					
Skin disinfectant (not chlorhexidine)	Yes	Observed available and valid skin disinfectant (1625.07)	219	57.1%	42.9%	0.0%

IV solution	Yes	Observed available and valid IV solution (1625.06)	219	69.4%	30.6%	0.0%
Resuscitation table (with heat source)	Yes	Observed available heat source (1622.02)	219	22.4%	77.6%	0.0%
Towels	No					
24-hour delivery care	Yes	Included in human resources index				
Stethoscope	Yes	Observed available stethoscope (1622.15)	219	75.8%	24.2%	0.0%
Incubator	Yes	Observed available incubator (1622.01)	219	9.1%	90.9%	0.0%
Chlorhexidine 4% gel or solution	Yes	Observed available and valid chlorhexidine (1625.08)	219	43.8%	56.2%	0.0%

LD = Labor and delivery

Potential labor and delivery human resources quality measure items from the WHO QoC Framework by category, their availability in the SPA dataset, definition with question number in the SPA health worker assessment, and univariate distribution in 219 facilities

Potential items from WHO QoC Framework	In SPA dataset	Definition	N	Proportion of facilities		
				Yes	No	Missing
1. Availability of health staff						
24-hour availability of staff	Yes	Is there a health care worker present at the facility at all times? (300) AND Is there a duty schedule or call list for 24-hour coverage? (301/302) [+]	219	52.5%	47.5%	0.0%
Up-to-date staffing policy	No					
On display roster	Yes	Combined with 24-hour availability of staff				
Triage and waiting time policy	No					
Are all posts in health facility filled	No					
Are all staff oriented to their functions, roles, and responsibilities	No					
All women who attend the facility for maternal health care receive attention within the appropriate time for their condition	No					
Clear communication channels to reach staff	No					
2. Appropriate skills and competencies of health staff						
Staff have received in-service training in last 12 months	Yes	All LD providers interviewed report receiving training or training updates on Labor and Delivery topics in past 2 years (502)	219	29.2%	70.8%	0.0%
Continuing professional development program	No					
Procedures and plans for recruitment, deployment, motivation, and retention of staff	Yes	All LD providers interviewed report having opportunities for promotion in their current job (805)	219	29.7%	70.3%	0.0%
		All LD providers interviewed report receiving a salary supplement (806)	219	87.2%	12.8%	0.0%
		All LD providers interviewed report receiving any non-monetary incentives (807)	219	72.6%	27.4%	0.0%
Periodic performance appraisal	Yes	All LD providers interviewed report receiving supervision with performance appraisal (803.03)	219	56.6%	43.4%	0.0%
Sufficient numbers of educated, competent staff	Yes	All LD providers interviewed report working 40 or fewer hours per week (800)	219	17.4%	82.6%	0.0%
Enabling, supportive environment	No					
Inter-professional collaborative practice	No					

Staff have a written job description	Yes	All LD providers interviewed report having a written job description (804)	218	6.9%	93.1%	0.5%
Staff have received supervision in past 3 months	Yes	All LD staff interviewed report receiving 1+ supervision visits in past six months (801-803)				
Team meetings held to review competencies and quality improvement activities	Yes	Does this facility routinely carry out quality assurance activities, are there any official record of these activities (440-441) +	219	18.3%	81.7%	0.0%
Staff interact with professional mentors to ensure clinical competence and improve performance	No					
Staff are engaged in quality improvement team meetings	No					
3. Managerial and clinical leadership through meetings and quality assurance						
Quality improvement plans	No					
Leadership structure	No					
Quality improvement team	No					
Regular collection of patient and provider satisfaction data	Yes	Does this facility have any system for determining clients' opinions about the health facility or its services (430) +	219	51.6%	48.4%	0.0%
At least one monthly meeting to review data, monitor quality improvement performance, make recommendations to address any identified problems	Yes	Does this facility routinely conduct maternal and/or neonatal death audits? (1617 AND 1618) +	219	53.0%	47.0%	0.0%
		Does this facility have routine facility management meetings? (410) +	219	67.6%	32.4%	0.0%
Accessible procedures and policies	No					
At least two annual meetings with stakeholders to review performance	Yes	Are there any routine meetings about facility activities with facility staff and community members (417-418) +	213	25.8%	74.2%	2.7%
Facility leaders trained in leadership and management	No					
Procedure for staff feedback to facility management	No					
Health facility leaders communicate the performance of the facility through established mechanisms for monitoring to all relevant staff	No					
Proportion of monthly meetings on the quality of care that were actually held in the preceding 12 months	No					

LD = labor and delivery

+ Item from the facility assessment

Potential labor and delivery technical process quality measure items from the Tripathi maternity quality of care index by category, their availability in the SPA dataset, definition with question number in the SPA labor and delivery observation instrument, and univariate distribution in 388 patients

Potential items from Tripathi index	In SPA dataset	Definition	N	Proportion of women who received action		
				Yes	No	Missing
1. Evidence-based practices						
Checks HIV status	Yes	Observed done (106)	377	82.0%	18.0%	2.8%
Asks whether woman has experienced vaginal bleeding	Yes	Observed done (105.01)	377	82.0%	18.0%	2.8%
Asks whether woman has experienced headaches or blurred vision	Yes	Observed done (105.03)	378	22.5%	77.5%	2.6%
Takes woman's pulse	Yes	Observed done (115)	382	48.2%	51.8%	1.5%
Takes woman's blood pressure	Yes	Observed done (116)	382	59.7%	40.3%	1.5%
Washes hands before any exam	Yes	Observed done (301)	384	62.5%	37.5%	1.0%
Wears gloves for vaginal exam	Yes	Observed done (122)	377	82.0%	18.0%	2.8%
Uses partograph	Yes	Observed done (206)	388	80.9%	19.1%	0.0%
Uses partograph correctly	Yes	Observed done (613)	315	54.3%	45.7%	18.8%
Prepares uterotonic for AMTSL	Yes	Observed done (223)	387	91.2%	8.8%	0.3%
Prepares newborn bag and mask	Yes	Observed done (226 AND 227 AND 228)	382	33.0%	67.0%	1.5%
Correctly administers uterotonic (1 min)	Yes	Observed done (312)	388	16.5%	83.5%	0.0%
Correctly administers uterotonic (3 min)	Yes	Observed done (312)	388	60.6%	39.4%	0.0%
Assesses placenta and membranes for completeness	Yes	Observed done (321)	382	78.5%	21.5%	1.5%
Assesses for perineal and vaginal lacerations	Yes	Observed done (322)	382	96.9%	3.1%	1.5%
Immediately dries baby with towel	Yes	Observed done (406)	382	99.0%	1.0%	1.5%
Kept baby skin-to-skin for 1 hour after birth	Yes	Observed done (416)	384	44.3%	55.7%	1.0%
Ties or clamps cord when pulsations stop, or 2-3 minutes after birth	Yes	Observed done (407)	375	67.2%	32.8%	3.4%
Takes mother's vital signs 15 minutes after birth	Yes	Observed done (412)	381	26.8%	73.2%	1.8%
Palpates uterus 15 minutes after birth	Yes	Observed done (413)	381	20.2%	79.8%	1.8%
Assists mother to breastfeed within one hour	Yes	Observed done (417a)	384	66.9%	33.1%	1.0%
2. Functional referral systems						
Emergency transport system [+]	Yes	Available ambulance with fuel observed (SPA 450 AND 453)	388	52.8%	47.2%	0.0%
3. Information systems						
Functional system for collecting health services data [+]	Yes	Does the facility have a system in place to regularly collect health services data and reports on it at least quarterly? (460 AND 461 AND 462)	388	95.1%	4.9%	0.0%

[+] Item from the facility assessment applied to individual level

Potential labor and delivery interpersonal process quality items from the WHO QoC Framework by category, their availability in the SPA dataset, definition with question number in the SPA labor and delivery instrument, and univariate distribution in 388 patients

Item	In SPA dataset	Definition	N	Proportion of women who received action		
				Yes	No	Missing
1. Effective provider-patient communication						
All women in labor and delivery should receive written and verbal information and counselling on: nutrition	No					
All women in labor and delivery are given the opportunity to discuss their concerns and preferences	Yes	Asks if woman (or support person) has any questions (104.3)	372	33.3%	66.7%	4.1%
All health care staff in labor and delivery demonstrate the following skills: active listening, asking questions, responding to questions, verifying the understanding of women and their families and supporting women in problem-solving.	Yes	Provider explained the procedure to woman (or support person) before proceeding during the initial client exam (113)	373	93.0%	7.0%	3.9%
		Provider explained what will happen in labor to woman during intermittent observation of first stage of labor (201)	384	76.3%	23.7%	1.0%
		Provider explained the procedure to woman (or support person) before proceeding with vaginal exam (215)	387	91.5%	8.5%	0.3%
All women in labor and delivery have their pregnancy progress documented in a partograph	Yes	Included in technical index				
All women in labor and delivery at the facility should have been introduced to the health facility staff and show good knowledge of the women's history and the care the care that had been given to date.	Yes	Checks client card or asks client her age, length of pregnancy, and parity (104.4)	382	95.8%	4.2%	1.5%
2. Patients treated with respect and dignity						
All procedures which require patient consent have a written record of consent	No					
All women undergoing examinations or procedures in the health facility report that their permission was sought before the exam or procedure was performed.	No					
All women are treated respectfully during labor and delivery	Yes	Any potentially harmful or inappropriate practices performed (603/604)	388	3.9%	96.1%	0.0%
All women in labor and delivery receive care in a private space [+]	Yes	Delivery space with visual and auditory privacy (1652) [+]	388	86.3%	13.7%	0.0%
All women in labor and delivery receive respectful, non-discriminatory services	Yes	Provider respectfully greeted the woman (104.1)	369	95.1%	4.9%	4.9%

All women in labor and delivery feel adequately informed by health staff regarding decisions taken about their care	Yes	Informs pregnant woman of findings (123)	373	89.8%	10.2%	3.9%
All women in labor and delivery were aware that they had the right to accept or refuse treatment.	No					
3. Emotional support						
All women who gave birth in the health facility had a companion of their choice during labor and childbirth	Yes	Provider encourages woman to have a support person present during labor (104.02)	376	35.9%	64.1%	3.1%
All companions to laboring women were satisfied with the orientation given on their role during labor and childbirth	No					
All women who give birth in the health facility were able to do so in the labor position of their choice.	Yes	At least once, provider encouraged/assists woman to ambulate and assume different positions during labor (203)	384	71.6%	28.4%	1.0%
All women who give birth in the health facility report having sufficient food and drink during labor.	Yes	At least once, provider encourages woman to consume fluids/food during labor (202)	385	65.2%	34.8%	0.8%
All women who give birth in the health facility were ambulatory during the first stage of labor.	Yes	Combined with labor position options above				
Women received sufficient pain relief	No					

[+] Item from the facility assessment applied to individual level

A.2 Correlation of each pair of potential items in each quality of care measure (Antenatal and labor and delivery)

Correlations between all potential antenatal care infrastructure quality measure items in 400 antenatal facilities[+]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1	1.00																										
2	0.08	1.00																									
3	-0.07	0.00	1.00																								
4	0.13	0.18	-0.06	1.00																							
5	0.49	0.18	-0.05	0.22	1.00																						
6	0.00	0.11	-0.04	0.07	-0.02	1.00																					
7	0.07	0.06	0.10	0.06	0.08	0.09	1.00																				
8	0.01	0.13	0.04	0.01	0.15	0.24	0.14	1.00																			
9	0.21	0.52	-0.02	0.09	0.30	0.06	0.13	0.24	1.00																		
10	0.07	0.26	-0.05	0.09	0.00	0.47	0.11	0.32	0.15	1.00																	
11	0.10	0.19	0.00	0.02	0.19	0.13	0.04	0.31	0.25	0.12	1.00																
12	0.04	0.04	0.05	0.12	0.08	0.10	0.07	0.15	0.10	0.10	0.23	1.00															
13	0.01	0.04	0.03	0.15	0.04	-0.02	-0.01	0.07	0.06	0.06	0.12	0.22	1.00														
14	0.10	0.15	0.03	0.03	0.08	-0.07	0.09	0.16	0.23	0.03	0.18	0.14	0.05	1.00													
15	0.23	0.14	0.04	0.10	0.29	0.08	0.13	0.12	0.23	0.04	0.21	0.05	0.04	0.13	1.00												
16	0.26	0.09	0.04	0.10	0.36	0.02	0.22	0.12	0.21	0.04	0.12	0.04	-0.03	0.10	0.53	1.00											
17	0.00	0.08	-0.03	0.02	0.09	0.13	0.20	0.10	0.05	0.13	0.07	0.05	0.00	-0.01	0.02	0.09	1.00										
18	0.09	0.04	0.03	0.05	0.09	0.11	0.11	0.08	0.08	0.12	0.07	0.01	0.10	0.11	0.07	0.11	0.14	1.00									
19	0.03	0.05	-0.01	0.00	0.01	0.03	0.10	0.09	0.08	0.09	0.00	0.05	0.08	-0.02	0.04	0.04	0.42	0.18	1.00								
20	-0.01	-0.02	-0.01	0.01	-0.05	0.01	0.00	0.11	0.07	0.06	0.06	0.12	0.14	0.11	0.03	-0.02	0.10	0.16	0.10	1.00							
21	0.10	0.19	0.00	0.02	0.19	0.13	0.04	0.31	0.25	0.12	1.00	0.23	0.12	0.18	0.21	0.12	0.07	0.07	0.00	0.06	1.00						
22	0.02	0.14	0.04	0.04	0.09	0.03	0.00	0.12	0.13	0.09	0.07	0.02	0.05	0.23	0.03	0.10	0.06	0.05	-0.04	0.08	0.07	1.00					
23	0.01	0.03	0.14	-0.06	-0.05	-0.05	0.10	0.11	0.11	0.05	0.06	0.05	0.12	0.36	0.08	0.10	-0.01	0.10	0.09	0.10	0.06	0.17	1.00				
24	-0.07	0.00	-0.01	0.00	-0.05	-0.04	0.01	0.04	-0.06	0.02	0.10	0.00	-0.02	-0.02	0.04	0.04	0.06	-0.02	-0.01	0.10	0.10	0.04	0.09	1.00			
25	0.21	0.07	0.06	0.02	0.23	-0.08	-0.02	-0.07	0.07	-0.09	0.13	0.02	0.00	0.00	0.13	0.10	-0.04	0.00	0.01	-0.03	0.13	-0.04	-0.05	0.06	1.00		
26	0.23	0.12	0.01	0.13	0.24	0.09	0.15	0.13	0.19	0.05	0.23	0.16	0.02	0.15	0.21	0.24	0.11	0.14	0.01	-0.03	0.23	0.12	0.13	0.07	0.02	1.00	

27	0.10	0.11	0.09	0.05	0.05	0.07	0.12	0.04	0.05	0.05	0.00	0.03	0.04	0.04	0.12	0.04	-0.01	0.03	-0.01	-0.08	0.00	0.08	0.05	-0.06	-0.04	0.05	1.00

Shaded cells indicate a correlation above the cut-off (φ=0.4)

Legend of potential items: Item number in the correlation table, item definition, N

1	*Adequate power*	*N=398*
2	*Running water in ANC room*	*N=393*
3	*Adequate sanitation facilities*	*N=400*
4	*Adequate communication systems*	*N=400*
5	*Available computer with internet access*	*N=365*
6	*Safe disposal of sharps available*	*N=400*
7	*Safe disposal of infectious waste available*	*N=400*
8	*Available disinfectant in ANC exam room*	*N=400*
9	*Available soap and running water or alcohol-based hand rub in ANC exam room*	*N=400*
10	*Latex gloves available*	*N=400*
11	*Guidelines for standard precautions available*	*N=400*
12	*Guidelines for ANC available*	*N=400*
13	*Visual job aids available*	*N=400*
14	*Blood pressure cuff/apparatus available*	*N=400*
15	*Rapid hemoglobin test available*	*N=400*
16	*Urine protein test available*	*N=400*
17	*Iron or folic acid or combination tablets available*	*N=400*
18	*Tetanus toxoid vaccine available*	*N=400*
19	*IPTp drug available*	*N=400*
20	*Insecticide treated bed nets available*	*N=400*
21	*Consultation table available for ANC*	*N=400*
22	*Scale available in ANC*	*N=400*
23	*Stethoscope available in ANC*	*N=400*
24	*Fetoscope available in ANC*	*N=400*
25	*At least 5 days/week of ANC service provided*	*N=400*
26	*Exam light available in ANC*	*N=400*
27	*Blank individual records available for ANC*	*N=400*

[+] Note that the number of correlations >0.4 in the table may be larger than the number cited in the text, as the table includes all potential items before removing items with a large proportion of missing data and low variability.

Correlations between all potential antenatal human resources quality measures items in 400 facilities[+]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1.00													
2	0.16	1.00												
3	0.13	0.13	1.00											
4	0.25	0.15	0.14	1.00										
5	0.00	0.08	0.13	0.08	1.00									
6	0.00	0.03	0.00	-0.01	0.18	1.00								
7	-0.06	-0.05	0.06	-0.04	-0.03	-0.01	1.00							
8	-0.08	-0.01	-0.15	-0.02	-0.01	0.03	-0.06	1.00						
9	-0.01	0.01	-0.07	0.12	0.01	-0.01	0.06	0.09	1.00					
10	-0.02	0.05	0.04	-0.02	0.01	0.03	0.11	0.01	0.11	1.00				
11	-0.06	-0.04	0.03	-0.09	0.00	-0.03	0.11	0.06	0.12	0.08	1.00			
12	-0.08	0.00	-0.11	-0.01	0.01	0.00	-0.05	0.79	0.11	0.04	0.08	1.00		
13	0.23	0.15	0.11	0.22	0.07	-0.06	-0.08	-0.06	0.01	-0.07	-0.07	-0.07	1.00	
14	0.14	0.00	-0.04	0.03	0.01	0.00	0.01	0.08	0.11	0.07	0.00	0.06	-0.01	1.00

Shaded cells indicate a correlation above the cut-off (φ=0.4)

Legend of potential items: Item number in the correlation table, item definition, N

1	*24-hour availability of staff*	*N=400*
2	*Quality assurance system in place*	*N=400*
3	*System in place for determining clients' opinions about the health facility or its services*	*N=400*
4	*Routinely maternal and/or neonatal death audits*	*N=360*
5	*Routine facility management meetings*	*N=400*
6	*Routine meetings between facility staff and community members*	*N=363*
7	*Providers received training or training updates on ANC topics in past 2 years*	*N=400*
8	*Technical support or supervision received at least once in the past six months*	*N=400*
9	*Procedures and plans for motivation of staff: Opportunities for promotion*	*N=400*
10	*Procedures and plans for motivation of staff: Receive at least one type of salary supplement*	*N=400*
11	*Procedures and plans for motivation of staff: non-monetary incentives*	*N=400*
12	*Periodic performance appraisal: at least one supervision with performance appraisal in the past six months*	*N=400*
13	*Sufficient numbers of educated, competent staff: staff work 40 or fewer hours per week*	*N=400*
14	*Staff have written job descriptions*	*N=400*

[+] Note that the number of correlations >0.4 in the table may be larger than the number cited in the text, as the table includes all potential items before removing items with a large proportion of missing data and low variability.

Correlations between potential antenatal care technical process quality measure items in 2043 antenatal observations[+]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
1	1.00																												
2	0.21	1.00																											
3	0.05	0.14	1.00																										
4	0.04	0.02	0.06	1.00																									
5	-0.01	0.31	0.11	0.08	1.00																								
6	0.01	0.02	0.08	0.44	0.10	1.00																							
7	0.00	0.11	0.08	0.46	0.19	0.38	1.00																						
8	0.07	0.20	0.11	0.08	0.28	0.03	0.07	1.00																					
9	0.00	-0.16	0.00	-0.03	-0.10	-0.02	-0.06	-0.04	1.00																				
10	0.01	0.17	0.04	0.00	0.17	0.01	0.07	0.14	0.01	1.00																			
11	0.00	0.00	0.02	0.18	0.03	0.10	0.19	0.12	-0.02	0.00	1.00																		
12	0.00	-0.03	-0.01	-0.06	0.04	-0.16	-0.10	-0.06	0.05	-0.03	-0.06	1.00																	
13	0.00	0.00	0.08	0.00	0.04	0.03	0.00	0.07	0.06	0.02	0.14	-0.05	1.00																
14	0.06	0.07	0.08	0.01	0.01	0.03	-0.01	0.07	0.04	0.03	-0.01	0.03	0.06	1.00															
15	0.09	0.14	0.08	-0.03	0.12	0.05	0.04	0.08	-0.05	0.02	0.03	0.00	-0.05	0.34	1.00														
16	0.03	0.09	0.03	0.00	0.04	0.00	-0.02	0.08	0.02	0.05	0.04	-0.04	0.09	0.50	0.28	1.00													
17	-0.02	-0.05	0.09	0.06	0.03	-0.01	0.05	0.03	0.04	-0.03	0.10	0.07	0.10	0.00	-0.01	0.00	1.00												
18	0.04	-0.04	0.09	0.03	0.05	0.01	0.04	0.11	0.02	0.00	0.21	0.09	0.38	0.09	0.09	0.10	0.13	1.00											
19	0.01	0.02	0.08	0.44	0.10	1.00	0.38	0.03	-0.02	0.01	0.10	-0.16	0.03	0.03	0.05	0.00	-0.01	0.01	1.00										
20	0.05	0.10	0.06	0.00	0.16	0.03	0.03	0.16	-0.01	0.17	0.02	-0.04	0.06	0.01	0.02	0.06	-0.05	0.08	0.03	1.00									
21	0.07	0.05	0.03	0.05	0.03	0.11	0.03	0.05	0.02	0.06	0.04	-0.02	0.00	0.08	0.08	0.05	0.06	0.06	0.11	0.08	1.00								
22	0.04	0.04	0.05	0.07	0.03	0.09	0.04	0.04	0.03	0.01	0.02	-0.03	0.02	0.04	0.05	0.06	0.00	0.04	0.09	0.06	0.46	1.00							
23	0.05	0.04	0.04	0.09	0.02	0.09	0.06	0.01	0.04	0.02	0.00	-0.01	0.01	0.07	0.05	0.05	0.10	0.08	0.09	0.07	0.59	0.42	1.00						
24	0.02	0.00	0.03	0.07	0.05	0.05	0.06	0.02	0.06	0.01	0.02	0.01	0.08	0.10	0.02	0.10	0.07	0.05	0.05	0.07	0.43	0.21	0.42	1.00					
25	0.10	0.07	0.00	0.04	0.01	0.09	0.02	0.01	-0.03	0.04	0.01	-0.03	0.06	0.01	0.03	0.03	-0.01	0.07	0.09	0.03	0.16	0.16	0.20	0.16	1.00				
26	0.10	0.09	-0.03	0.02	-0.04	-0.02	0.00	0.06	-0.01	0.03	-0.01	0.03	-0.02	0.01	-0.04	0.02	0.02	0.00	-0.02	0.00	0.08	0.01	0.03	0.09	0.06	1.00			
27	0.14	0.11	0.00	0.02	0.06	0.09	0.04	0.02	0.01	0.00	-0.03	-0.07	-0.02	0.05	0.04	0.05	-0.06	-0.03	0.09	0.04	0.16	0.13	0.12	0.08	0.18	0.08	1.00		
28	0.10	0.12	0.02	0.06	0.03	0.06	0.05	0.09	-0.01	0.05	0.00	-0.01	0.01	0.07	0.03	0.05	0.06	0.06	0.06	0.06	0.60	0.35	0.49	0.41	0.24	0.57	0.24	1.00	
29	0.09	0.04	0.02	0.07	0.04	0.10	0.05	0.01	0.05	0.03	0.01	-0.02	0.01	0.08	0.04	0.08	0.08	0.03	0.10	0.09	0.70	0.57	0.70	0.58	0.27	0.17	0.25	0.45	1.00

Shaded cells indicate a correlation above the cut-off (φ=0.4)

Legend of potential items: Item number in the correlation table, item definition, N

1 *Took client history: all four items* *N=2043*

2	*Took client history: at least two items*	*N=2043*
3	*Checked height*	*N=2043*
4	*Gave/referred for hemoglobin test*	*N=2043*
5	*Gave/referred for HIV test*	*N=2043*
6	*Gave/referred for Blood group test*	*N=2043*
7	*Gave/referred for Syphilis test*	*N=2043*
8	*Gave/referred for tetanus vaccine given*	*N=2043*
9	*Checked fetal heart beat*	*N=2043*
10	*Gave/prescribed IPTp*	*N=2043*
11	*Functional ambulance with fuel observed*	*N=2043*
12	*Functional system for collecting health services data in place*	*N=2043*
13	*Checked weight*	*N=2043*
14	*Checked for edema*	*N=2043*
15	*Performed breast exam*	*N=2043*
16	*Checked pallor for anemia*	*N=2043*
17	*Measured fundal height*	*N=2043*
18	*Checked blood pressure*	*N=2043*
19	*Gave/referred for urine test*	*N=2043*
20	*Gave/prescribed iron and/or folic acid*	*N=2043*
21	*Assessed significant symptoms: bleeding*	*N=2043*
22	*Assessed significant symptoms: fever*	*N=2043*
23	*Assessed significant symptoms: headache*	*N=2043*
24	*Assessed significant symptoms: swelling*	*N=2043*
25	*Assessed significant symptoms: fatigue*	*N=2043*
26	*Assessed significant symptoms: fetal movement*	*N=2043*
27	*Assessed significant symptoms: persistent cough*	*N=2043*
28	*Assessed significant symptoms: Any*	*N=2043*
29	*Assessed significant symptoms: At least three*	*N=2043*

[+] Note that the number of correlations >0.4 in the table may be larger than the number cited in the text, as the table includes all potential items before removing items with a large proportion of missing data and low variability.

Correlations between potential antenatal interpersonal process quality measure items in 2043 antenatal observations[+]

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	1.00								
2	0.03	1.00							
3	-0.01	-0.01	1.00						
4	0.01	-0.01	0.20	1.00					
5	0.12	-0.04	0.01	-0.02	1.00				
6	0.07	-0.01	0.03	-0.02	0.16	1.00			
7	0.05	0.02	-0.08	-0.02	0.08	0.13	1.00		
8	0.05	-0.05	-0.04	0.04	0.10	0.14	0.20	1.00	
9	0.05	-0.03	0.06	0.02	0.18	0.20	0.01	0.06	1.00

Shaded cells indicate a correlation above the cut-off (φ=0.4)

Legend of potential items: Item number in the correlation table, item definition, N

1	*Used visual aids*	*N=2036*
2	*Visual and auditory privacy in antenatal room*	*N=2043*
3	*Looked at patient card*	*N=2042*
4	*Wrote on patient card*	*N=2043*
5	*Asked if patient had any questions*	*N=2043*
6	*Counselled on importance of four antenatal visits*	*N=2043*
7	*Counselled on any danger signs*	*N=2043*
8	*Counselled on at least one aspect of birth planning*	*N=2043*
9	*Informed patient about progress of pregnancy*	*N=2043*

[+] Note that the number of correlations >0.4 in the table may be larger than the number cited in the text, as the table includes all potential items before removing items with a large proportion of missing data and low variability.

Correlations between potential labor and delivery care infrastructure quality measure items in 219 labor and delivery facilities[+]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
1	1.00																																
2	0.15	1.00																															
3	-0.13	-0.02	1.00																														
4	0.07	0.10	-0.04	1.00																													
5	0.51	0.13	-0.15	0.18	1.00																												
6	-0.03	0.17	-0.01	-0.05	-0.06	1.00																											
7	-0.05	0.02	-0.01	-0.05	0.02	0.06	1.00																										
8	0.19	0.19	-0.04	-0.04	0.11	0.06	0.00	1.00																									
9	0.08	0.37	-0.05	-0.01	0.08	0.10	0.02	0.12	1.00																								
10	0.10	0.42	-0.01	-0.05	-0.01	0.28	0.04	0.34	0.24	1.00																							
11	0.18	0.10	-0.07	0.10	0.27	-0.03	0.03	0.18	0.15	0.17	1.00																						
12	0.06	-0.04	-0.11	-0.02	0.10	0.07	0.15	0.00	0.03	0.04	0.19	1.00																					
13	0.21	0.14	-0.14	0.14	0.29	-0.04	0.07	0.04	0.12	0.00	0.14	-0.02	1.00																				
14	0.14	0.05	-0.03	-0.04	0.14	0.10	0.07	0.08	0.19	0.13	0.18	0.19	0.08	1.00																			
15	0.12	-0.04	-0.07	0.07	0.26	-0.11	0.05	0.03	-0.04	-0.04	0.07	0.05	0.16	0.04	1.00																		
16	0.26	0.15	0.01	0.05	0.26	0.01	0.03	0.13	0.18	0.13	0.11	0.08	0.12	0.10	0.10	1.00																	
17	0.13	0.07	-0.04	0.16	0.25	0.02	0.13	0.12	0.04	0.09	0.12	0.13	0.18	0.11	-0.02	0.47	1.00																
18	-0.05	-0.06	-0.03	0.07	0.03	-0.04	0.08	-0.05	0.04	-0.04	0.08	0.08	0.13	0.07	-0.04	0.19	0.16	1.00															
19	0.08	0.25	-0.01	0.12	0.07	-0.01	-0.01	-0.04	0.07	-0.01	0.04	0.00	-0.03	-0.03	0.05	0.01	-0.04	-0.03	1.00														
20	0.08	-0.02	-0.01	0.12	0.07	-0.01	-0.01	0.12	-0.05	-0.01	0.14	0.10	-0.14	-0.03	0.05	0.11	0.07	-0.03	-0.01	1.00													
21	0.07	0.07	-0.03	-0.03	0.13	0.11	-0.06	-0.03	0.07	-0.03	0.09	-0.01	0.01	0.01	0.02	0.10	0.08	0.17	-0.03	-0.03	1.00												
22	0.33	0.19	-0.05	-0.06	0.30	0.02	0.07	0.27	0.22	0.05	0.21	0.10	0.14	0.27	0.08	0.17	0.08	0.11	-0.05	-0.05	0.04	1.00											
23	-0.02	-0.05	-0.03	0.16	0.03	-0.04	-0.10	-0.03	-0.08	-0.03	0.09	0.07	-0.03	-0.07	0.13	0.14	0.04	0.17	-0.03	-0.03	0.02	-0.07	1.00										
24	0.15	-0.06	-0.06	0.12	0.26	-0.01	0.00	0.10	0.10	-0.08	0.20	0.08	0.23	0.19	0.08	0.12	0.05	0.08	-0.06	-0.06	-0.01	0.21	-0.01	1.00									

25	0.06	-0.03	-0.02	0.04	0.11	-0.02	-0.04	0.04	0.07	-0.02	0.16	-0.10	-0.02	0.08	0.00	0.04	-0.10	-0.05	-0.02	-0.02	-0.04	0.09	-0.04	0.27	1.00										
26	0.15	-0.05	-0.02	0.04	0.16	-0.04	-0.03	0.05	0.03	-0.03	0.15	0.15	0.04	0.28	0.07	-0.01	0.03	0.10	-0.02	-0.02	0.03	0.22	0.03	0.25	-0.04	1.00									
27	0.46	0.13	-0.04	0.06	0.57	-0.13	0.10	0.05	0.15	0.09	0.24	0.03	0.24	0.11	0.24	0.26	0.22	0.08	0.07	0.07	0.09	0.28	0.04	0.18	0.04	0.17	1.00								
28	0.23	0.00	0.11	-0.02	0.22	0.02	0.08	0.19	0.06	0.06	0.17	0.17	0.09	0.23	0.14	0.14	0.04	0.09	0.01	0.11	-0.05	0.18	-0.05	0.18	0.12	0.14	0.24	1.00							
29	0.06	0.05	0.04	-0.01	0.01	-0.02	0.07	0.04	0.01	0.01	0.07	-0.04	0.06	0.03	-0.03	-0.04	-0.17	0.02	0.04	0.15	-0.03	0.02	-0.12	0.13	0.11	-0.06	0.05	0.11	1.00						
30	0.41	0.03	-0.07	0.12	0.56	-0.01	0.05	0.07	0.03	0.07	0.19	0.07	0.27	0.10	0.14	0.19	0.25	0.06	0.05	0.05	0.03	0.19	0.03	0.21	0.01	0.13	0.48	0.16	0.02	1.00					
31	0.10	0.02	0.06	-0.03	0.04	0.00	0.06	0.13	0.26	0.12	0.16	-0.03	-0.01	0.22	0.02	0.14	0.18	-0.03	-0.06	-0.06	0.06	0.16	-0.04	0.06	-0.02	0.02	0.11	0.13	0.07	0.09	1.00				
32	0.28	-0.04	0.03	0.06	0.42	0.04	0.03	0.00	-0.02	0.04	0.14	0.03	0.23	0.09	0.07	0.04	0.06	0.02	-0.15	0.03	0.08	0.15	0.00	0.15	0.05	0.08	0.25	0.16	0.12	0.37	0.00	1.00			
33	0.19	0.06	0.09	0.04	0.11	0.05	0.06	0.09	0.05	0.11	0.14	0.16	0.05	0.16	0.07	-0.03	0.07	-0.06	-0.01	0.09	0.05	0.08	0.05	0.09	-0.19	0.17	0.14	0.25	0.05	0.10	0.15	0.21	1.00		

Shaded cells indicate a correlation above the cut-off (φ=0.4)

Legend of potential items: Item number in the correlation table, item definition, N

1 *Adequate power*	*N=219*
2 *Running water in labor and delivery room*	*N=218*
3 *Adequate sanitation facilities*	*N=219*
4 *Adequate communication systems*	*N=219*
5 *Available computer with internet access*	*N=201*
6 *Safe disposal of sharps available*	*N=219*
7 *Safe disposal of infectious waste available*	*N=219*
8 *Available disinfectant in labor and delivery room*	*N=219*
9 *Available soap and running water or alcohol-based hand rub in labor and delivery room*	*N=219*
10 *Latex gloves available*	*N=219*
11 *Guidelines for standard precautions available*	*N=219*
12 *Guidelines for labor and delivery available*	*N=219*
13 *Delivery light available*	*N=219*
14 *Delivery pack available*	*N=219*
15 *Suction apparatus available*	*N=219*
16 *Manual vacuum extractor available*	*N=219*
17 *D&C kit available*	*N=219*
18 *Neonatal bag and make (Size 0 and 1) available*	*N=219*
19 *Delivery bed available*	*N=219*
20 *Partograph available*	*N=219*
21 *Infant scale available*	*N=219*
22 *Blood pressure apparatus available*	*N=219*

23	*Newborn antibiotic ointment available (tetracycline)*	*N=219*
24	*Injectable antibiotic available (Ceftriaxone)*	*N=219*
25	*Injectable uterotonic available (Oxytocin)*	*N=219*
26	*Injectable Magnesium Sulfate available*	*N=219*
27	*Injectable Hydralzaine available*	*N=219*
28	*Skin disinfectant available*	*N=219*
29	*IV solution available*	*N=219*
30	*Neonatal heat source available*	*N=219*
31	*Stethoscope available*	*N=219*
32	*Incubator available*	*N=219*
33	*Chlorhexidine available*	*N=219*

[+] Note that the number of correlations >0.4 in the table may be larger than the number cited in the text, as the table includes all potential items before removing items with a large proportion of missing data and low variability.

Correlations between potential labor and delivery human resources quality measure items in 219 labor and delivery facilities [+]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1.00													
2	0.18	1.00												
3	0.09	0.11	1.00											
4	0.30	0.09	0.26	1.00										
5	-0.01	0.16	0.21	0.19	1.00									
6	-0.02	0.03	0.02	-0.03	0.27	1.00								
7	-0.07	0.07	0.06	-0.09	0.02	0.03	1.00							
8	-0.06	-0.04	-0.01	-0.14	0.05	0.10	0.21	1.00						
9	-0.04	-0.14	-0.11	0.01	-0.02	0.17	0.16	0.18	1.00					
10	-0.05	-0.07	0.00	-0.12	0.02	0.06	0.12	0.16	0.06	1.00				
11	-0.09	-0.04	-0.01	-0.10	0.00	-0.10	0.09	0.28	0.05	0.02	1.00			
12	-0.05	-0.01	-0.04	-0.18	-0.04	0.05	0.28	0.79	0.22	0.21	0.28	1.00		
13	0.17	0.00	0.10	0.11	-0.06	-0.16	0.06	0.08	-0.06	0.03	-0.02	0.03	1.00	
14	0.02	0.02	-0.05	0.02	0.09	0.06	-0.04	0.02	0.00	-0.01	-0.05	-0.04	0.02	1.00

Shaded cells indicate a correlation above the cut-off (φ=0.4)

Legend of potential items: Item number in the correlation table, item definition, N

1	*24-hour availability of staff*	*N=219*
2	*Quality assurance system in place*	*N=219*
3	*System in place for determining clients' opinions about the health facility or its services*	*N=219*
4	*Routinely maternal and/or neonatal death audits*	*N=219*
5	*Routine facility management meetings*	*N=219*
6	*Routine meetings between facility staff and community members*	*N=213*
7	*Providers received training or training updates on ANC topics in past 2 years*	*N=219*
8	*Technical support or supervision received at least once in the past six months*	*N=219*
9	*Procedures and plans for motivation of staff: Opportunities for promotion*	*N=219*
10	*Procedures and plans for motivation of staff: Receive at least one type of salary supplement*	*N=219*
11	*Procedures and plans for motivation of staff: non-monetary incentives*	*N=219*
12	*Periodic performance appraisal: at least one supervision with performance appraisal in the past six months*	*N=219*
13	*Sufficient numbers of educated, competent staff: staff work 40 or fewer hours per week*	*N=219*
14	*Staff have written job descriptions*	*N=218*

[+] Note that the number of correlations >0.4 in the table may be larger than the number cited in the text, as the table includes all potential items before removing items with a large proportion of missing data and low variability.

Correlations between potential labor and delivery technical process quality measure items in 388 labor and delivery observations[+]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	1.00																						
2	-0.14	1.00																					
3	0.10	0.11	1.00																				
4	0.10	0.11	1.00	1.00																			
5	0.12	0.08	0.08	0.08	1.00																		
6	0.17	0.06	0.02	0.02	0.06	1.00																	
7	0.14	0.09	0.06	0.06	0.13	0.64	1.00																
8	-0.01	-0.05	-0.13	-0.13	0.15	0.11	0.17	1.00															
9	0.04	0.04	-0.08	-0.08	0.01	0.04	0.00	0.11	1.00														
10	0.02	-0.04	0.05	0.05	0.00	0.05	0.14	-0.05	-0.02	1.00													
11	-0.11	-0.13	-0.06	-0.06	-0.21	0.02	-0.07	0.10	-0.07	-0.06	1.00												
12	0.03	-0.07	-0.04	-0.04	0.05	-0.04	-0.02	0.07	-0.03	0.03	-0.01	1.00											
13	0.15	0.00	0.09	0.09	0.04	0.03	0.03	-0.03	-0.10	-0.05	0.02	0.13	1.00										
14	-0.07	0.04	-0.05	-0.05	-0.13	0.00	0.02	-0.05	0.07	-0.03	0.07	0.14	-0.04	1.00									
15	0.06	0.00	0.14	0.14	0.09	0.03	-0.02	0.08	0.00	0.01	-0.05	0.25	0.13	0.35	1.00								
16	0.08	0.11	-0.03	-0.03	0.03	-0.01	0.06	0.10	0.02	0.01	-0.13	0.09	0.03	-0.08	-0.03	1.00							
17	-0.01	-0.03	-0.05	-0.05	0.08	-0.07	-0.04	-0.05	-0.06	-0.02	0.05	0.06	0.04	-0.08	0.01	0.06	1.00						
18	0.11	-0.03	0.06	0.06	0.06	0.11	0.00	0.06	0.14	0.19	-0.09	-0.03	0.08	-0.13	-0.01	0.19	-0.01	1.00					
19	-0.04	0.02	-0.10	-0.10	-0.15	0.00	-0.08	-0.01	0.11	-0.10	0.21	0.03	0.02	0.07	-0.12	-0.05	0.07	-0.04	1.00				
20	-0.11	0.10	0.08	0.08	0.03	-0.05	0.01	0.06	-0.04	0.01	0.09	0.10	0.07	-0.21	-0.11	0.19	0.02	0.07	0.09	1.00			
21	0.02	-0.06	0.05	0.05	0.19	0.26	0.28	0.22	0.05	0.02	-0.11	0.05	0.05	0.07	0.13	0.18	-0.09	0.07	0.06	-0.03	1.00		
22	0.00	-0.05	0.02	0.02	0.04	0.15	0.16	0.17	0.10	-0.01	-0.09	0.06	-0.09	0.06	0.00	0.16	0.01	0.06	0.14	0.09	0.36	1.00	
23	0.11	-0.10	0.03	0.03	0.04	-0.04	0.02	0.07	-0.14	0.00	-0.03	0.14	0.06	-0.26	-0.04	0.21	0.01	0.14	-0.19	0.17	-0.01	0.04	1.00

Shaded cells indicate a correlation above the cut-off (φ=0.4)

Legend of potential items: Item number in the correlation table, item definition, N

1	*Available ambulance with fuel observed*	*N=388*
2	*Functional system for collecting health services data*	*N=388*
3	*Checked HIV status*	*N=377*
4	*Asked whether woman has experienced vaginal bleeding*	*N=377*
5	*Asked whether woman has experienced headaches or blurred vision*	*N=378*
6	*Took woman's pulse*	*N=382*
7	*Took woman's blood pressure*	*N=382*

8	*Washed hands before any exam*	*N=384*
9	*Wore gloves for vaginal exam*	*N=377*
10	*Used partograph*	*N=388*
11	*Used partograph correctly*	*N=315*
12	*Prepared uterotonic for Active Management of the Third Stage of Labor*	*N=387*
13	*Prepared newborn bag and mask*	*N=382*
14	*Correctly administered uterotonic (1 min)*	*N=388*
15	*Correctly administered uterotonic (3 min)*	*N=388*
16	*Assessed placenta and membranes for completeness*	*N=382*
17	*Assessed for perineal and vaginal lacerations*	*N=382*
18	*Immediately dried baby with towel*	*N=382*
19	*Kept baby skin-to-skin for 1 hour after birth*	*N=384*
20	*Tied or clamped cord when pulsations stop, or 2-3 minutes after birth*	*N=375*
21	*Took mother's vital signs 15 minutes after birth*	*N=381*
22	*Palpated uterus 15 minutes after birth*	*N=381*
23	*Assisted mother to breastfeed within one hour*	*N=384*

[+] Note that the number of correlations >0.4 in the table may be larger than the number cited in the text, as the table includes all potential items before removing items with a large proportion of missing data and low variability.

Correlations between potential labor and delivery technical process quality measure items in 388 labor and delivery observations [+]

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.00											
2	0.12	1.00										
3	0.22	0.29	1.00									
4	0.10	0.34	0.26	1.00								
5	0.12	0.10	0.04	0.12	1.00							
6	-0.02	0.00	0.01	-0.09	0.04	1.00						
7	-0.06	-0.02	-0.04	0.01	0.10	0.00	1.00					
8	0.13	0.25	0.15	0.11	0.02	-0.02	-0.02	1.00				
9	0.12	0.41	0.25	0.31	0.07	0.01	0.01	0.25	1.00			
10	0.21	0.07	0.07	0.03	0.08	-0.03	0.09	0.08	0.03	1.00		
11	0.17	0.05	0.11	0.05	0.11	-0.04	-0.08	0.16	0.24	0.16	1.00	
12	0.18	0.07	0.12	0.08	0.21	-0.03	0.13	0.05	0.13	0.20	0.34	1.00

Shaded cells indicate a correlation above the cut-off (φ=0.4)

Legend of potential items: Item number in the correlation table, item definition, N

1	*Asked if woman (or support person) has any questions*	*N=372*
2	*During initial client exam, provider explained the procedure to woman (or support person) before proceeding*	*N=373*
3	*During the first stage of labor, provider explained the need procedure to woman (or support person) before proceeding*	*N=384*
4	*Before initiating a vaginal exam, provider explained the procedure to woman (or support person) before proceeding*	*N=387*
5	*Checks client card or asks client her age, length of pregnancy, and parity*	*N=382*
6	*No potentially harmful or inappropriate practices performed*	*N=388*
7	*Delivery space has visual and auditory privacy*	*N=388*
8	*Respectfully greeted the woman*	*N=369*
9	*Informed pregnant woman of findings*	*N=373*
10	*Encouraged woman to have a support person present during labor*	*N=376*
11	*At least once, encouraged/assisted to ambulate and assume different positions during labor*	*N=384*
12	*At least once, encouraged to consume fluids/food during labor*	*N=385*

[+] Note that the number of correlations >0.4 in the table may be larger than the number cited in the text, as the table includes all potential items before removing items with a large proportion of missing data and low variability.

Appendix B

Appendix B.1 Bivariate associations of antenatal quality items with facility characteristics

Bivariate associations of antenatal infrastructure quality items with facility characteristics in 400 antenatal facilities

	Hospitals N=86	Health Centers N=316	p-value		Public N=266	Private N=134	p-value		Urban N=69	Rural N=331	p-value
Adequate power at facility [+]	75.3%	23.0%	<0.001		27.9%	46.6%	<0.001		69.6%	26.7%	<0.001
Adequate communication system	93.0%	76.8%	<0.01		80.1%	80.6%	0.9		94.2%	77.3%	<0.01
Safe disposal of infectious waste available	51.2%	41.1%	0.1		42.5%	44.8%	0.66		56.5%	40.5%	<0.05
Available disinfectant in ANC exam room	69.8%	55.4%	<0.05		57.1%	61.2%	0.44		71.0%	55.9%	<0.05
Available soap and running water or alcohol-based hand rub in ANC exam room	81.4%	46.2%	<0.001		45.1%	70.9%	<0.001		75.4%	49.2%	<0.001
Latex gloves available	86.0%	86.0%	0.99		88.7%	80.6%	<0.05		89.9%	85.2%	0.31
Guidelines for standard precautions available	55.8%	35.4%	<0.01		39.5%	40.3%	0.87		49.3%	37.8%	0.08
Guidelines for ANC available	50.0%	35.4%	<0.05		38.7%	38.1%	0.9		34.8%	39.3%	0.49
Visual job aids available	161.6%	50.6%	0.07		52.3%	54.5%	0.67		46.4%	54.4%	0.23
Blood pressure cuff/apparatus available	75.6%	71.3%	0.44		65.4%	85.8%	<0.001		78.3%	71.0%	0.22
Rapid hemoglobin test available	26.7%	5.1%	<0.001		6.8%	15.7%	<0.01		18.8%	7.9%	<0.01
Iron or folic acid or combination tablets observed or reported available in ANC	96.5%	91.4%	0.11		92.9%	91.8%	0.7		94.2%	92.1%	0.56
Tetanus toxoid vaccine available	79.1%	68.2%	<0.05		68.8%	73.9%	0.48		71.0%	70.4%	0.92
ITNs available	75.6%	76.8%	0.82		77.4%	74.6%	0.53		60.9%	79.8%	<0.01
Scale available in ANC	91.9%	89.2%	0.47		86.8%	95.5%	<0.001		95.7%	88.5%	0.08
Stethoscope available in ANC	68.6%	73.9%	0.33		66.2%	85.8%	<0.001		69.6%	73.4%	0.51
At least 5 days/week of ANC service provided	65.1%	40.4%	<0.001		44.7%	47.8%	0.57		69.6%	40.8%	<0.001
Exam light available in ANC	46.5%	18.8%	<0.001		21.8%	30.6%	0.05		44.9%	20.5%	<0.001
Blank individual records available for ANC	40.7%	35.0%	0.33		33.5%	41.8%	0.1		31.9%	37.2%	0.41

[+] N = 398

ANC=Antenatal Care

Bivariate associations of antenatal human resources quality items with facility characteristics in 400 antenatal facilities

	Hospitals N= 86	Health Centers N=314	p-value	Public N=266	Private N=134	p-value	Urban N=69	Rural N=331	p-value
Staff present 24/7 with observed duty roster	80.2%	30.6%	<0.001	35.7%	52.2%	<0.01	71.0%	35.0%	<0.001
Quality assurance meetings held	29.1%	10.2%	<0.001	13.2%	16.4%	0.38	18.8%	13.3%	0.23
System for receiving client feedback and opinion	70.9%	44.9%	<0.001	49.2%	53.0%	0.48	59.4%	48.6%	0.10
Management meetings once a month or more	76.7%	62.7%	<0.05	65.8%	65.7%	0.98	71.0%	64.7%	0.31
Community meetings once a month or more	15.1%	22.3%	0.12	22.9%	16.4%	0.14	13.0%	22.4%	0.07
All providers at the facility received training on antenatal care in past 2 years	73.3%	8.6%	0.42	23.3%	20.1%	0.34	20.3%	23.0%	0.63
All providers at the facility have opportunities for promotion	27.9%	33.1%	0.36	33.8%	28.4%	0.27	26.1%	33.2%	0.25
All providers at the facility receive some kind of salary supplement	83.7%	87.9%	0.31	90.2%	80.6%	<0.01	79.7%	88.5%	<0.05
All providers at the facility receive some kind of non-monetary incentive	67.4%	76.4%	0.09	72.2%	79.1%	0.13	60.9%	77.3%	<0.01
All providers at the facility were supervised with performance appraisal past 6	60.5%	67.8%	0.20	65.0%	68.7%	0.47	56.5%	68.3%	0.06
All providers at the facility work 40 or fewer hours per week	47.7%	13.7%	<0.001	16.9%	29.1%	<0.01	50.7%	14.8%	<0.001
All providers at the facility have a written job description	11.6%	9.6%	0.57	11.3%	7.5%	0.23	14.5%	9.1%	0.17

Bivariate associations of antenatal technical process quality items with facility characteristics in 2043 patient observations in 400 facilities

	Hospitals N=516	Health Centers N=1527	p-value	Public N=1462	Private N=581	p-value	Urban N=403	Rural N=1640	p-value
All history questions asked	3.9%	3.7%	0.88	3.6%	4.3%	0.42	5.5%	3.4%	<0.05
Checked height	5.6%	5.4%	0.83	5.1%	6.4%	0.24	6.0%	5.3%	0.61
Hemoglobin test performed or referred	11.6%	0.9%	<0.001	1.4%	9.1%	<0.001	6.2%	3.0%	<0.01
HIV test performed or referred	29.1%	28.6%	0.82	27.2%	32.5%	<0.05	25.3%	29.5%	0.10
Tetanus vaccine prescribed or given	31.2%	27.4%	0.10	25.2%	36.3%	<0.001	33.7%	27.1%	<0.01
Checked fetal heart beat	82.4%	80.2%	0.27	78.5%	86.2%	<0.001	81.4%	80.5%	0.70
IPTp given or prescribed	58.7%	64.5%	<0.05	62.8%	63.7%	0.71	54.8%	65.1%	<0.001
Available ambulance with fuel observed	79.8%	16.6%	<0.001	25.0%	51.6%	<0.001	61.0%	25.6%	<0.001
Functioning health services data system	95.7%	97.6%	<0.05	96.7%	98.3%	0.06	95.3%	97.6%	<0.05
Weighed client	79.8%	74.7%	<0.05	72.7%	84.3%	<0.001	72.5%	76.9%	0.06
Checked client for edema	67.4%	63.4%	0.10	64.9%	63.2%	0.46	68.2%	63.5%	0.07
Examined client's breasts	45.7%	37.5%	<0.01	41.9%	33.7%	<0.01	52.9%	36.3%	<0.001
Measured fundal height	42.6%	36.7%	<0.05	37.1%	41.0%	0.10	40.0%	37.7%	0.41
Checked client blood pressure	64.7%	51.2%	<0.001	46.6%	74.7%	<0.001	57.8%	53.8%	0.15
Gave or prescribed iron and/or folic acid	85.5%	86.2%	0.66	86.8%	84.2%	0.12	85.1%	86.3%	0.54
Any danger signs assessed	48.3%	47.7%	0.82	47.6%	48.4%	0.76	52.4%	46.7%	<0.05

Bivariate associations of antenatal interpersonal process quality items with facility characteristics in 2043 patient observations

	Hospitals N=516	**Health Centers N=1527**	**p-value**		**Public N=1462**	**Private N=581**	**p-value**		**Urban N=403**	**Rural N=1640**	**p-value**
Used visual aids [+]	6.2%	9.9%	<0.05		9.7%	7.3%	0.09		7.2%	9.4%	0.16
Visual and auditory privacy in antenatal room	91.9%	97.6%	<0.001		97.5%	92.8%	<0.001		97.5%	95.9%	0.12
Asked if client has any questions ‡	85.4%	78.6%	<0.01		80.2%	80.7%	0.77		84.4%	79.3%	<0.05
Discussed importance of 4 antenatal visits	16.7%	18.5%	0.36		17.5%	19.3%	0.35		17.9%	18.0%	0.93
Counseled on any danger signs	52.7%	43.4%	0.62		45.4%	46.6%	<0.001		20.8%	14.8%	<0.01
Counseled on at least 1 aspect of birth preparation	73.4%	74.2%	0.74		73.1%	76.4%	0.12		69.7%	75.1%	<0.05
Informed patient about progress of pregnancy	62.0%	61.2%	0.73		60.9%	62.5%	0.52		65.0%	60.5%	0.10

[+] N= 2036
‡ N=2042

Appendix C

Appendix C.1 Unstandardized results for Aim 2

Associations of quality of care elements and covariates with patient satisfaction in increasingly complex models (unstandardized coefficients)

	1	2	3	4
	Simple linear regression models	Linear mixed model	Simple ML path model	Full ML path model
Facility level				
Infrastructure	0.04 (0.02) **	0.03 (0.03)	0.04 (0.03)	0.01 (0.03)
Human Resources	-0.02 (0.02)	-0.02 (0.03)	-0.03 (0.04)	-0.05 (0.03)
Technical	0.01 (0.02)	0.01 (0.03)	-0.02 (0.03)	-0.04 (0.03)
Interpersonal	0.04 (0.02) **	0.04 (0.03)	0.05 (0.03) *	0.06 (0.03) **
Hospital (ref: Health Center)	0.03 (0.01) **	0.02 (0.00) **	NA	0.04 (0.01) **
Public (ref: Private)	-0.02 (0.01) **	0.02 (0.00) **	NA	-0.02 (0.01) **
			R^2=0.02	R^2=0.10
Patient level				
Technical	0.01 (0.02)	0.00 (0.02)	-0.01 (0.04)	-0.00 (0.04)
Interpersonal	0.03 (0.02) **	0.03 (0.02)	0.02 (0.03)	0.02 (0.03)
First ANC visit (ref: Not first ANC visit)	0.00 (0.01)	0.00 (0.00)	NA	0.00 (0.01)
Attended secondary school (ref: Did not attend secondary school)	-0.02 (0.01) **	-0.02 (0.01) **	NA	-0.02 (0.01) **
Multipara (ref: Primipara)	0.00 (0.01)	-0.00 (0.01)	NA	-0.00 (0.01)
Closest facility to home (ref: Not closest facility to home)	-0.01 (0.01)	-0.00 (0.01)	NA -	-0.00 (0.01)
			R^2=0.00	R^2=0.01

*p<0.10; **p<0.05

Column 1 expresses associations as unstandardized linear regression coefficients with standard error.
Column 2 accounts for clustering at facility level but does not include covariates. Associations are expressed as unstandardized linear regression coefficients with standard error.

Column 3 includes direct effects of all quality elements on patient satisfaction and indirect effects of infrastructure and human resources on patient satisfaction through technical and interpersonal process. Associations are expressed as unstandardized path coefficients with standard error.

Column 4 includes all quality elements as in Column 3 and adds covariates[31]. Associations are expressed as unstandardized path coefficients with standard error.

[31] Facility level covariates are level (hospital vs health center) and operating authority (public vs private). Patient level covariates are number of antenatal care visits (First ANC vs later ANC), education (attended secondary school vs not), parity (first pregnancy vs later pregnancy), and distance (attending ANC at the closest facility to home vs not).

Appendix C.2 Unstandardized results for Aim 3

Associations of quality of care elements and covariates with intended delivery location in increasingly complex models (unstandardized coefficients)

	1	2	3	4
	Simple logistic regression models	Logistic mixed models	Simple ML path model	Full ML path model
Facility level				
	Unstandardized lnOR (SE)	Unstandardized β (SE)	Unstandardized β (SE)	Unstandardized β (SE)
Infrastructure	0.92 (0.40) **	0.96 (0.56) *	0.87 (0.65)	0.00 (0.62)
Human Resources	1.58 (0.48) **	1.68 (0.74) **	1.56 (0.85) *	0.67 (0.70)
Technical	0.91 (0.39) **	0.79 (0.62)	-0.35 (1.34)	-0.35 (1.34)
Interpersonal	0.54 (0.40)	0.42 (0.60)	0.74 (1.23)	0.86 (1.24)
Hospital (ref: Health Center)	1.23 (0.19) **	1.29 (0.24) **	NA	1.63 (0.30) **
Public (ref: Private)	-0.16 (0.14)	-0.20 (0.23)	NA	0.02 (0.23)
Density	-0.06 (0.03) **	-0.09 (0.05) *	NA	-0.06 (0.05)
			R^2=0.05	R^2=0.34
Patient level				
	Unstandardized lnOR (SE)	Unstandardized lnOR (SE)	Unstandardized lnOR (SE)	Unstandardized lnOR (SE)
Technical	0.92 (0.35) **	0.92 (0.49) *	0.43 (0.99)	0.30 (1.01)
Interpersonal	0.28 (0.34)	0.05 (0.46)	-0.66 (0.79)	-0.77 (0.83)
First ANC visit (ref: Not first ANC visit)	0.07 (0.13)	0.04 (0.17)	NA	0.10 (0.18)
Attended secondary school (ref: Did not attend secondary school)	-0.39 (0.15) **	-0.51 (0.17) **	NA	-0.57 (0.18) **
Multipara (ref: Primipara)	0.58 (0.14) **	0.61 (0.16) **	NA	0.60 (0.17) **
Closest facility to home (ref: Not closest facility to home)	-0.05 (0.24)	0.13 (0.26)	NA	0.18 (0.28)
			R^2=0.00	R^2=0.05

*p<0.10; **p<0.05

Column 1 presents simple logistic regressions of intention to deliver at the same facility on each covariate separately. Associations are expressed as unstandardized logistic regression coefficients with standard error.

Column 2 presents multivariable logistic mixed model to account for clustering at the facility level. Facility level associations are expressed as unstandardized linear regression coefficients with standard error. Patient level associations are expressed as unstandardized logistic regression coefficients with standard error.

Column 3 includes direct effects of all quality elements on intention to deliver at the same facility and indirect effects of infrastructure and human resources on intention to deliver at the same facility through technical and interpersonal process. Facility level associations are expressed as unstandardized path coefficients with standard error. Patient level association are expressed as unstandardized logistic regression coefficients.

Column 4 includes all quality elements as in Column 3 and adds covariates[32]. Facility level associations are expressed as unstandardized path coefficients with standard error, patient level association are expressed as unstandardized logistic regression coefficients with standard error.

[32] Facility level covariates are level (hospital versus health center), operating authority (public versus private), and delivery facility density (number of labor and delivery facilities within a 10 km radius). Patient level covariates are number of antenatal care visits (First ANC versus later ANC), education (attended secondary school versus not), parity (first pregnancy versus later pregnancy), and distance (attending ANC at the closest facility to home versus not).

Appendix D

Appendix D.1 Correlation of antenatal infrastructure items with process scores: technical and interpersonal

Correlation of antenatal infrastructure items with facility average technical and interpersonal process scores at 412 facilities

	Technical		Interpersonal	
	Correlation coefficient	**p-value**	**Correlation coefficient**	**p-value**
Adequate power at facility	0.20	<0.001	0.02	0.39
Adequate communication system	0.18	<0.001	0.02	0.31
Safe disposal of infectious waste available	0.03	0.21	-0.02	0.32
Available disinfectant in ANC exam room	0.11	<0.001	0.02	0.49
Available soap and running water or alcohol-based hand rub in ANC exam room	0.20	<0.001	0.03	0.24
Latex gloves available	0.04	0.10	-0.04	0.11
Guidelines for standard precautions available	0.12	<0.001	0.03	0.20
Guidelines for ANC available	0.12	<0.001	-0.04	0.06
Visual job aids available	0.02	0.26	-0.04	0.09
Blood pressure cuff/apparatus available	0.26	<0.001	0.00	0.88
Rapid hemoglobin test available	-0.01	0.74	0.11	<0.001
Iron or folic acid or combination tablets observed or reported available in ANC	0.04	0.06	0.03	0.24
Tetanus toxoid vaccine available	0.03	0.24	-0.08	<0.01
ITNs available	0.05	<0.05	-0.04	0.09
Scale available in ANC	0.15	<0.001	0.02	0.35
Stethoscope available in ANC	0.04	0.07	-0.01	0.60
At least 5 days/week of ANC service provided	0.13	<0.001	-0.01	0.82
Exam light available in ANC	0.12	<0.001	-0.01	0.76
Blank individual records available for ANC	-0.09	<0.001	0.01	0.75

Appendix D.3 Correlation of antenatal human resources items with process scores: technical and interpersonal

Correlation of antenatal human resource items with facility average technical and interpersonal process scores at 412 facilities

	Technical		Interpersonal	
	Correlation coefficient	**p-value**	**Correlation coefficient**	**p-value**
24-hour availability of staff	0.23	<0.001	-0.03	0.25
Staff have received in-service training in last 24 months	0.01	0.72	0.04	0.07
All interviewed staff members receive some kind of salary supplement	-0.06	<0.01	0.05	<0.05
All interviewed staff members receive non-monetary incentives	-0.04	0.06	0.08	<0.01
All interviewed staff members see opportunities for promotion	-0.02	0.44	0.01	0.60
All interviewed staff members have received supervision in the past 3 months	-0.03	0.23	0.02	0.31
Sufficient numbers of educated, competent staff	0.12	<0.001	0.02	0.33
Staff have a written job description	0.01	0.80	0.07	<0.01
Quality assurance meetings held	0.03	0.18	0.00	0.83
Regular collection of patient and provider satisfaction data	0.13	<0.001	0.01	0.75
Existence of facility management meeting	0.02	0.36	0.01	0.59
Existence of community-facility meetings	-0.05	0.02	-0.06	<0.01

Appendix E

Appendix E.1 IRB approval letter

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NOT HUMAN SUBJECTS RESEARCH
DETERMINATION NOTICE
STUDENT PROJECTS

Date: March 7, 2018

To: Sara Riese

Re: **PhD Dissertation Student Project Title:** "Associations of antenatal care structure and process quality with outcomes in Malawi"

The JHSPH IRB reviewed the IRB Office Determination Request Form for Secondary Data Analysis (received March 2, 2018) on **March 7, 2018**. We have determined that the proposed activity described in your request form will involve secondary analysis of an existing, de-identified, publicly available data set to examine associations between dimensions of facility quality of maternal health care in Malawi. Thus, the proposed activity does not qualify as human subjects research as defined by DHHS regulations 45 CFR 46.102, and does not require IRB oversight.

You are responsible for notifying the JHSPH IRB of any future changes that might involve human subjects and require IRB oversight.

If you have any questions regarding this determination, please contact the JHSPH IRB Office at (410) 955-3193 or via email at jhsph.irboffice@jhu.edu.

/teb

cc
Anne Duggan, ScD
Faculty Advisor / Vice Chair for Research / Professor
Department of Population, Family and Reproductive Health
Johns Hopkins Bloomberg School of Public Health

Curriculum Vitae

SARA B. RIESE
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EDUCATION

Ph.D. candidate	2014-present	Department of Population, Family and Reproductive Health JOHNS HOPKINS UNIVERSITY, BLOOMBERG SCHOOL OF PUBLIC HEALTH, BALTIMORE, MD
M.P.H.	2008	Department of Sociomedical Sciences COLUMBIA UNIVERSITY, MAILMAN SCHOOL OF PUBLIC HEALTH, NEW YORK, NY
M.I.A.	2008	COLUMBIA UNIVERSITY, SCHOOL OF INTERNATIONAL AND PUBLIC AFFAIRS, NEW YORK, NY
B.A.	2001	Sociology UNIVERSITY OF CALIFORNIA AT BERKELEY, BERKELEY, CA

TEACHING EXPERIENCE

JOHNS HOPKINS UNIVERSITY, BLOOMBERG SCHOOL OF PUBLIC HEALTH

Department of Population, Family and Reproductive Health, Teaching Assistant

- Reproductive and Perinatal Epidemiology, Spring 2016, Professors Donna Strobino and Caroline Moreau
- Applications in Program Monitoring and Evaluation, Spring 2016, Professors Sarah Crowne and Anne Palaia
- Maternal and Child Health Legislation and Programs, Fall 2015, Professor Holly Grason

PROFESSIONAL EXPERIENCE

UNIVERSITY RESEARCH CO., LLC
BETHESDA, MD
2016-current *Senior Technical Advisor, Implementation Research*

- Collaborates with country programs to develop and conduct implementation research in the areas of HIV/AIDS, RMNCH, TB, and nutrition
- Provides technical support to RMNCH components of health, including participating in the development of a BEmONC training curriculum in Uganda
- Provides research expertise to bilateral and global projects, including HRH2030
- Member of the URC Institutional Review Board

2013-2016 *Research Advisor, Translating Research into Action Project (TRAction)*

- Supported a portfolio of implementation research studies on integrated Community Case Management, Performance Based Incentives, and Task-shifting for c-sections

- Developed and contributed to research materials for study on topics including case study methodology, impact evaluation, and policy analysis
- Utilized innovative approaches for dissemination and uptake of implementation research findings, including development of policy advocacy strategies

2010-2013 *Technical Advisor*

- Provided technical support on diverse topics to country programs: HIV/AIDS, maternal/child health, family planning, community case management, quality improvement, implementation research
- Collaborated on implementation research protocol development for PMTCT activities in Uganda
- Provided technical assistance on the roll-out of Option B+ to regional hospitals in Uganda through the SUSTAIN project
- Provided oversight to Benin child survival project including managing implementation of two KAP surveys, and all operations research activities. Research assessed a quality improvement collaborative approach to improve performance and retention of Community Health Workers in Benin
- Led a Global Fund-funded evaluation of Benin's TB Control Program

INTERNATIONAL CENTER FOR AIDS CARE AND TREATMENT PROGRAMS (ICAP)
NEW YORK, NY
2007-2010 *Senior Program Officer*

- Supported scale-up of PMTCT services in Tanzania, Cote d'Ivoire and Nigeria from 279 sites in 2008 to 611 sites in 2010
- Led quality improvement initiatives resulting in improved quality of care, increasing maternal ARV prophylaxis coverage by 21% and HIV exposed infant enrollment by 25% from 2008 to 2010 in ICAP Tanzania programs
- Provided support for operations research, such as an assessment of determinants of loss to follow-up in HIV-positive women enrolled in PMTCT and their infants in 3 hospitals in Swaziland
- Contributed to the development of quality improvement initiatives in adherence and retention and laboratory activities

AFRICAN SERVICES COMMITTEE
NEW YORK, NY
2005-2006 *Independent Living Skills Coordinator*

- Coordinated psychosocial support and skills-building programs for HIV+ clients
- Managed routine data and reporting for Risk Reduction activities
- Conducted client needs assessments

CARTER CENTER, GUINEA WORM ERADICATION PROGRAM
UPPER WEST REGION, GHANA
2005 *International Technical Advisor*

- Worked in cooperation with Ghana Health Service to lead the eradication program in the Upper West Region of Ghana, resulting in a 73% reduction in Guinea Worm cases from 2005 to 2006
- Managed budget of $30,000 annually for Regional Guinea Worm Eradication activities
- Collaborated with government and local organizations to improve the Eradication effort

PEACE CORPS
BURKINA FASO, WEST AFRICA
2002-2004 Community Health and Development Volunteer

LANGUAGES AND SKILLS

French: Proficient, written and spoken • Software: Microsoft Office, Stata, MPlus, ArcGIS, Atlas.ti • Excellent interpersonal, organizational and cross-cultural skills

AFFILIATIONS

Patient Reviewer, Patient-Centered Outcomes Research Institute (PCORI) • Member, American Public Health Association

PRESENTATIONS

Oral Presentations

Mobile Tools for Family Planning in Benin: "Texting for maternal wellbeing". Oral Presentation at 2014 "Throughout the Reproductive Life Course: Opportunities and Challenges for Empowering Girls and Women" meeting by Evidence to Action Project, MCHIP, and USAID. Washington, DC.

Improving community health indicators through application of an innovative quality improvement approach in Benin. Oral Presentation at 2013 APHA Annual Meeting, Boston, MA.

Poster Presentations

The Impact of the Quality Improvement Approach on Prevention of Mother-to-Child Transmission of HIV (PMTCT) Outcomes in Benin. Poster at 2012 International AIDS Conference, Washington DC.

Improving Retention, Adherence and Psychosocial Support within PMTCT Services: A Toolkit for Health Workers for Adaptation in sub-Saharan Africa. E-Poster at 2011 International AIDS Conference, Rome, Italy. [E-poster A-361-0210-02820]

Assessing Quality of the PMTCT Program at Tumbi Regional Hospital, Pwani, Tanzania. E-Poster at 2010 International AIDS Conference, Vienna, Austria. [E-Poster A-240-0156-11724]

Developing A Public Health Approach To Infant Feeding In The Context Of HIV: A Facility Assessment Of The AFASS Criteria. Oral presentation at 2008 HIV/AIDS Implementers Meeting. [Abstract 1628]

A Unique Approach to Continuous Quality Improvement: The ICAP Standards of Care (SOC). Poster Presentation at 2008 HIV/AIDS Implementers Meeting. [Abstract 505]

New Models for Technology Transfer: Utilization of a Wiki for Continuing HIV Education and Cross-Site Communication. Poster Presentation at XVII International AIDS Conference, Mexico City, Mexico. [Poster THPE1023].

PUBLICATIONS

Gergen J, Josephson E, Vernon C, Ski S, **Riese S**, Bauhoff S, Madhavan S. *Measuring and paying for quality of care in performance-based financing: Experience from seven low and middle-income countries (Democratic Republic of Congo, Kyrgyzstan, Malawi, Mozambique, Nigeria, Senegal and Zambia).* Journal of Global Health, December 2018; Vol. 8, No. 2.

Seigler A, Roberts L, Balch E, Bargues E, Bhalla A, Bills C, Dzeng E, Epelboym Y, Foster T, Fulton L, Gallagher M, Gastolomendo J, Giorgi G, Habtehans S, Kim J, McGee B, McMahan A, **Riese S**, Santamaria-Schwartz R, Walsh F, Wahlstrom J, Wedels, J. *Media coverage of violent deaths in Iraq: An opportunistic capture-recapture assessment.* Prehospital and Disaster Medicine, July-Aug 2008; Vol 23: 369-371.

AWARDS AND HONORS

2018	Carl Swan Schulz Endowment Fund
2017	Donald A. Cornely Scholar
2015, 2016	Willian Endowment for Excellence in Science
	Kann Trowbridge Award